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UNIVERSITY OF ALBERTA

ORIGIN AND GEOLOGIC SIGNIFICANCE OF HOLOCENE TEMPERATE CARBONATES, BRITISH COLUMBIA CONTINENTAL SHELF

BY

JOHN SCOTT CAREY ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science.

DEPARTMENT OF GEOLOGY

Edmonton, Alberta

Fall 1992

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Origin and Geologic Significance of Holocene Temperate Carbonates, British Columbia Continental Shelf" submitted by John Scott Carey in partial fulfillment of the requirements for the degree of Master of Science in Geology.

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Date: June 19, 1992

ABSTRACT

The surficial sediments of an area of approximately 4000 Km^2 in Hecate Strait, British Columbia continental shelf are composed predominantly of calcium carbonate. The deposit is a discontinuous unit consisting of coarse shell debris, typically less than 1m thick, overlying the Tertiary bedrock. Carbonate sediments are restricted to water depths of less than 50m and are closely associated with rock and gravel substrates. The faunas in these sediments are predominantly bivalves, barnacles and bryozoans, comprising a typical "foramol" assemblage. The organisms are not in life position, but are generally found within or near their natural habitat. Radiocarbon dates on surficial material range from modern to 1500 years BP. These sediments are similar in age, composition, and distribution to those of Cook Bank, which is located approximately 250 km to the south. Sediment cores from Cook Bank indicate that carbonate accumulation has been occurring for at least 7500 years. High wave and tidal energy abundant hard substrates in both areas favour suspension-feeding biogenic carbonate producers. Relatively high rates of carbonate production, in combination with very low terrigenous sediment input, allow the formation of carbonate sediments in a high latitude environment. The sedimentation rate is generally low (< 10cm/1000 years), due to rapid destruction of material by physical abrasion, bioerosion and dissolution.

The occurrence of carbonates on the British Columbia continental shelf is a result of the glacial and post-glacial history of the region. Low sea level stands at the close of the Holocene exposed much of the shelf to subaerial erosion, exposing bedrock and winnowing glacial tills to a gravelly lag, producing substrates suitable for colonization by the biogenic carbonate producers. The ensuing transgression trapped nearly all sediment in the coastal areas, preventing the dilution of the carbonate deposits by terrigenous material. Similar deposits in ancient rocks may be associated with major sea level transgressions, and may be considered coarse-grained equivalents of a "condensed section". Many laterally extensive coquina beds in ancient sequences may be temperate carbonates formed in transgressive and high stand systems tracts.

ACKNOWLEDGEMENTS

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I. INTRODUCTION

A. Purpose and Scope of the Study

Over the past twenty-five years, the literature on temperate carbonate sediments has expanded enormously. Yet a number of geologic problems persist in our understanding of non-tropical carbonates. There has been little work on the evolution of temperate carbonate platforms over time; important exceptions include discussions of faunal variation (Wilson, 1988), and the potential for "drowning" of platforms (Simone and Carranante, 1988). Temperate carbonates may also be important in recognizing changes in relative sea level. Pilkey (1968) stated that the modern surface of the Atlantic continental shelf of the United States would appear, if preserved, as a $CaCO_3$ rich layer in the stratigraphic column. If Pilkey's assertion is generally applicable to temperate continental margins which have experienced major sea level rises, this may be an important consideration when interpreting past carbonate horizons in temperate sequences. This study will address these issues through an examination of Holocene carbonate sediments on the continental shelf of British Columbia.

The purpose of this study is to augment our understanding of the biologic, geologic and oceanographic factors controlling the distribution of carbonate sediments of the British Columbia continental shelf, and to use this information to aid the interpretation of ancient deposits.

B. Previous Work

1. Distribution of Modern Temperate Carbonates

"It has been a common rule of thumb for geologists to equate carbonates of the past with warm climatic conditions." Fairbridge (1967) recognized the danger in the assumption that ancient carbonates necessarily formed under warm climatic conditions, but did not challenge the view of modern carbonate occurrence that it reflected. Although shallow water carbonates had been reported in temperate areas, (e.g. Carrigy, 1956; Boillot, 1965; Niino and Emery, 1966) significant shallow water carbonate sedimentation was thought to be restricted to tropical and subtropical conditions (Figure 1a). Chave (1967) disputed this, demonstrated that carbonate sedimentation was widespread on temperate shelves, and postulated that the primary control on carbonate deposition was not temperature but the degree of dilution by terrigenous material.

Since the publication of the seminal work of Chave (1967), the literature on temperate carbonates has increased tremendously. Carbonate sediments are now known to cover extensive areas of temperate continental shelves throughout the world (Figure 1b). Widespread carbonate sedimentation has been documented on the continental shelves of southern Australia (Waas et al, 1970; Marshall and Davies, 1978; Collins, 1988), New Zealand (Nelson et al., 1982, 1988b), southern Africa (Siesser, 1971) , the Mediterranean Sea

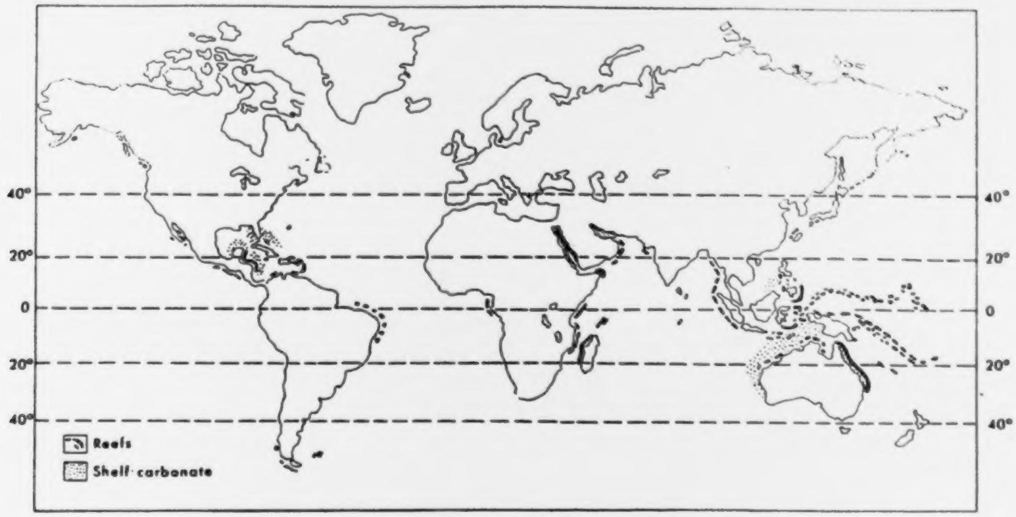

40°
20°
0
20°
40°
40°
20°
0
20°
40°
Reefs
Shelf carbonate

Figure 1a. Distribution of modern marine carbonate sediments in shallow water. Modified from Wilson (1975).

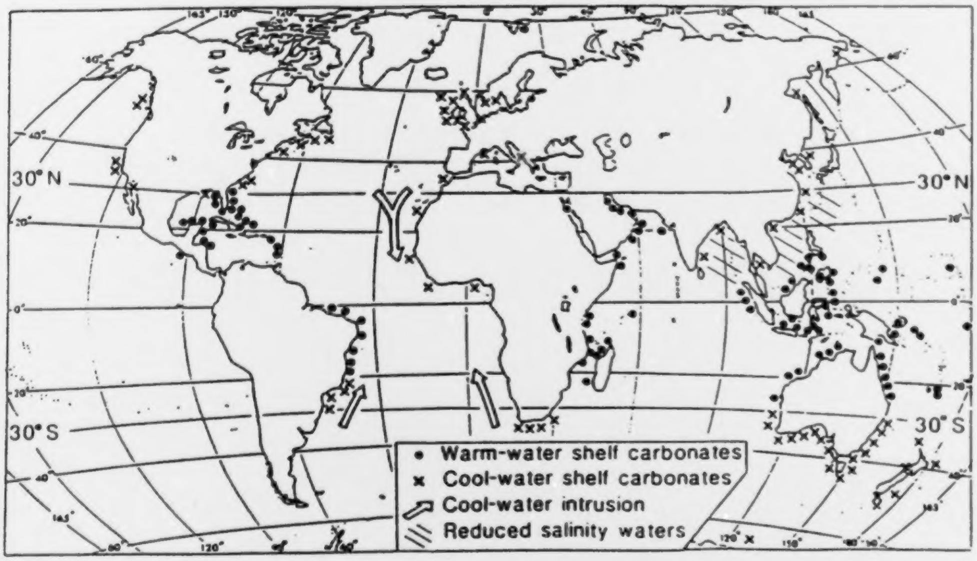

30° N
30° N
30° S
30° S
• Warm-water shelf carbonates
× Cool-water shelf carbonates
Cool-water intrusion
Reduced salinity waters

Figure 1b. Distribution of modern marine sediments in shallow water, distinguishing cool-water and warm-water types. Modified from Nelson (1988).

(Milliman et al., 1972; Caulet, 1972, Alavi et al., 1989), the British Isles (Lees et al., 1969; Hommeril, 1971; Farrow, 1974; Farrow et al., 1984; Scoffin, 1988), southern Brazil (Vicalvi and Milliman, 1977), and both the Atlantic and Pacific coasts of North America (Muller and Milliman, 1973; Leonard and Cameron, 1981; Chave, 1967; Hoskin and Nelson, 1969; Nelson and Bornhold, 1983) of North America. It is interesting to note that many areas of the continental shelf described as "relict" by Emery (1968) are now recognized as areas of active carbonate sedimentation.

2. Sedimentological and Biological Characteristics

As a consequence of the increased documentation of temperate carbonates, it is now possible to differentiate the sedimentological and biological characteristics of these sediments from those of tropical and subtropical carbonates. Lees and Buller (1972) made the first attempt to subdivide modern carbonate deposits into cool and warm water types. They coined the terms "foramol", referring to the importance of foraminifera and mollusks in temperate carbonate occurrences, and "chlorozoan" to describe tropical and subtropical carbonates dominated by green algae and hermatipic corals. The term "foramol" has come into general usage, although some authors (e.g. Nelson et al., 1988b) have felt that "bryomol", referring to the importance of bryozoans in these sediments, would be more descriptive. Carannante et al.

(1988) suggested a further subdivision of the foramol assemblage into a warm temperate "rhodalgal" facies, with abundant coralline algal bindstone and rhodoliths, and a cool temperate "molechfor" facies in which molluscs, echinoids and foraminifera are important sediment producers. The rhodalgal facies is characteristic of the transition zone between the other two, and is found in the Mediterranean Sea, the southeastern coast of Brazil, and in deeper water in tropical areas (Carannante et al., 1988). The name would also apply to the Rottnest Shelf in southwestern Australia, described by Collins (1988).

Since Lees and Buller (1972), many papers have contrasted the foramol and chlorozoan assemblages in modern sediments, eg. Leonard et al. (1981); Nelson and Bornhold (1984); and Nelson (1988). Some of the most striking characteristics of the foramol assemblage are listed below.

1. Calcareous green algae and hermatipic corals are absent.
2. Mollusks and forams are ubiquitous; red algae, bryozoans and barnacles may be abundant.
3. Carbonate grains are almost wholly skeletal. Ooids and aggregate grains are absent and peloids are rare; interclasts may occur.

4. Sand and gravel size material usually predominates. Bass Basin, between Australia and Tasmania, is a striking exception (Blom and Alsop, 1988).
5. Calcite usually dominates over aragonite.
6. Terrigenous material may be abundant.
7. Sedimentation rates are typically much lower (<10 cm/1000 yrs) than in tropical settings.

There has also been an improvement in our understanding of the factors controlling the distribution of these sediments, the most important of which is the terrigenous sediment supply (Chave, 1967). Lees (1975) demonstrated that the assemblage of skeletal grains and types of non-skeletal grains, present in water depths of less than 100m could be predicted by the water temperature and salinity conditions. Chlorozoan assemblages were found to be restricted to areas where minimum surface temperatures exceeded 15°C, and mean temperatures exceeded 18°C. However, the foramol assemblage extended into warmer seas where salinity was depressed below normal marine conditions. On temperate shelves where terrigenous input is low, the rate of sediment accumulation is controlled by the rate of biogenic production and the rates of destruction by bioerosion and dissolution. High rates of biogenic carbonate production have been found in areas with abundant rocky or gravelly substrates, which allow epifaunal organisms to attach themselves, and high wave or tidal energy (Boillot, 1965; Wilson, 1979; Nelson et al., 1988b). Tidal sand bedforms, owing to the instability of the substrate, have been found to be relatively barren of living organisms (Wilson, 1981). Thus, continental shelves where gravel and exposed rock are common, such as that of British Columbia, are commonly areas of carbonate deposition.

3. Ancient Temperate Shelf Carbonates

Along with the increasing awareness of the characteristics and conditions of formation of modern temperate carbonates, there has been some recognition of ancient examples. Some of the best documented are the Tertiary carbonates of New Zealand (Nelson, 1978; Kamp et al., 1988; Kamp and Nelson, 1988) and southern Australia (Quilty,1977;1980; James and Bone, 1991), areas where analogous modern sediments are being deposited nearby. Other examples include the Miocene of Europe (Studencki, 1979; Carranante et al., 1981) and California (Cuffey et al., 1981), and the Permo-Carboniferous of Tasmania (Rao, 1981) and Malaysia (Rao, 1988).

Given the considerable extent of these deposits on modern continental shelves, documented ancient examples are remarkably scarce (Nelson, 1988). This may be due in part to lack of recognition, as interpretation of carbonate facies is commonly based on tropical models (e.g. Wilson, 1975; James, 1984). However, Ziegler et al. (1984) noted that most carbonate occurrences in the geologic record were deposited within 35° north or south of the equator, and 99% within 45° of the equator; high latitude carbonates were conspicuously rare. However, the slow rate of deposition and common association with terrigenous sediments of temperate carbonates, reduces the probability of their yielding thick sedimentary sections, and they may have been omitted from Ziegler's maps.

4. The Carbonate Sediments of the British Columbia Shelf

Skeletal carbonates on the British Columbia continental shelf were first documented by Nelson and Bornhold (1983) on the Scott Shelf or Cook Bank, northwest of Vancouver Island. They found that in the vicinity of the Scott Islands, and on the continental shelf to the north, the carbonate content in the surficial sediments often exceeds 50%, and locally reaches 98%. An abrupt decline in carbonate to the south of the islands coincides with a transition from a rocky, topographically complex sea floor underlain by Mesozoic volcanics in the Scott Islands region, to a relatively flat seafloor underlain by flat-lying sedimentary rocks. Sediments are concentrated in depressions, bedrock hollows and joints, the troughs of megaripples, and between gravel ridges.

The presence of the carbonate sediments was attributed to the very low rate of terrigenous sediment supply and to local conditions which favour the growth of calcareous organisms. The following characteristics of this part of the shelf were regarded as favourable to biogenic carbonate production.

1. Abundant bedrock outrop and gravelly surficial sediment provides a stable substrate, suitable for encrusting organisms, such as bryozoans and barnacles.
2. High wave energy and strong tidal currents, prevent fine-grained sediment from settling, thus aiding filter-feeding organisms.
3. Upwelling may bring nutrient-rich, cold water to the area, enhancing biological productivity.

These sediments were found to comprise a typical foramol assemblage with bivalves, barnacles and bryozoans predominating in the shallow water (<100 m) and benthic foraminifera in deeper waters. A striking feature of the sediments is the relatively young radiocarbon ages obtained from the shells. Even the most strongly corroded and bored specimens dated at 800 to 1000 BP. This indicates that shell breakdown can occur very rapidly, which they felt would result in a very low sedimentation rate.

Young and Nelson (1985; 1988) investigated the effects of boring and dissolution on the carbonate sediments on Scott Shelf in greater detail. Algae, sponges, fungi, bacteria and naticid gastropods were all found to be important bioeroders. In addition to accelerating the physical breakdown of shell material, the borings increase the porosity and surface area of the shells, aiding in chemical breakdown by the process of maceration. Maceration, which results in characteristic etching patterns and breakdown of shells, is caused by periodic undersaturation of sea water with respect to calcium carbonate (Alexandersson, 1975; 1979). Aragonitic bivalves may be preferentially removed from the sediment by this process (Young and Nelson, 1985, 1988).

C. Objectives of the Study

This paper documents the occurrence of calcium carbonate rich sediments in Hecate Strait, between the Queen Charlotte Islands and the mainland. These sediments will be compared to the surficial and core samples obtained from Cook Bank. The specific objectives of this study are:

1. to map the distribution of the carbonate sediments in both study areas;
2. to account for this distribution with respect to
   a) biologic factors - the preferred habitats of the organisms responsible for both the genesis and destruction of the carbonates;

   b) oceanographic factors - the effects of waves and tidal currents (erosion, transportation, and deposition) and marine chemistry (dissolution);
   c) geologic factors - the effects of the last glaciation and subsequent sea level rise in providing conditions favourable to carbonate deposition;

3. To determine the age of these sediments and their rate of accumulation;
4. To discuss the effects of sea level rise on possible changes in the composition and character of these sediments during the Holocene;
5. To discuss the preservation potential of this type of deposit in the rock record; and
6. To discuss the significance of similar deposits within a sequence stratigraphic context.

II. LOCATION AND GEOLOGICAL SETTING

The study areas lie on the British Columbia continental shelf, and along the active margin of the North American plate (Figure 2). North of the triple junction in Queen Charlotte Sound, there is a strike-slip plate boundary with the Pacific Plate, and to the south there is a convergent boundary with the Explorer plate. Both study areas lie within the Hecate Depression, a coastal trough separating the Coast Mountains of mainland British Columbia from the insular mountains of the Queen Charlotte Islands and Vancouver Island (Holland, 1964).

A. Hecate Strait

The area under investigation in Hecate Strait extends from 53°30' to 54°50' N and from 130°30' to 131°40' W, an area of approximately 11500 km^2 (Figure 3). This is the central portion of Hecate Strait, and includes the shallow bank areas of southern Dogfish Bank and Laskeek Bank which are relatively flat and slope gently to the east. To the south and southwest there is an abrupt change in physiographic character to a region of highly irregular topography.

Most of Hecate Strait is underlain by the Skonun Formation, a thick sequence of Tertiary sedimentary rocks (Shouldice, 1973), although parts of Laskeek Bank are underlain by volcanics (Barrie, pers. comm., 1992). Graham Island is underlain predominantly by sedimentary rocks of the Skonun Formation and by Masset Formation volcanics

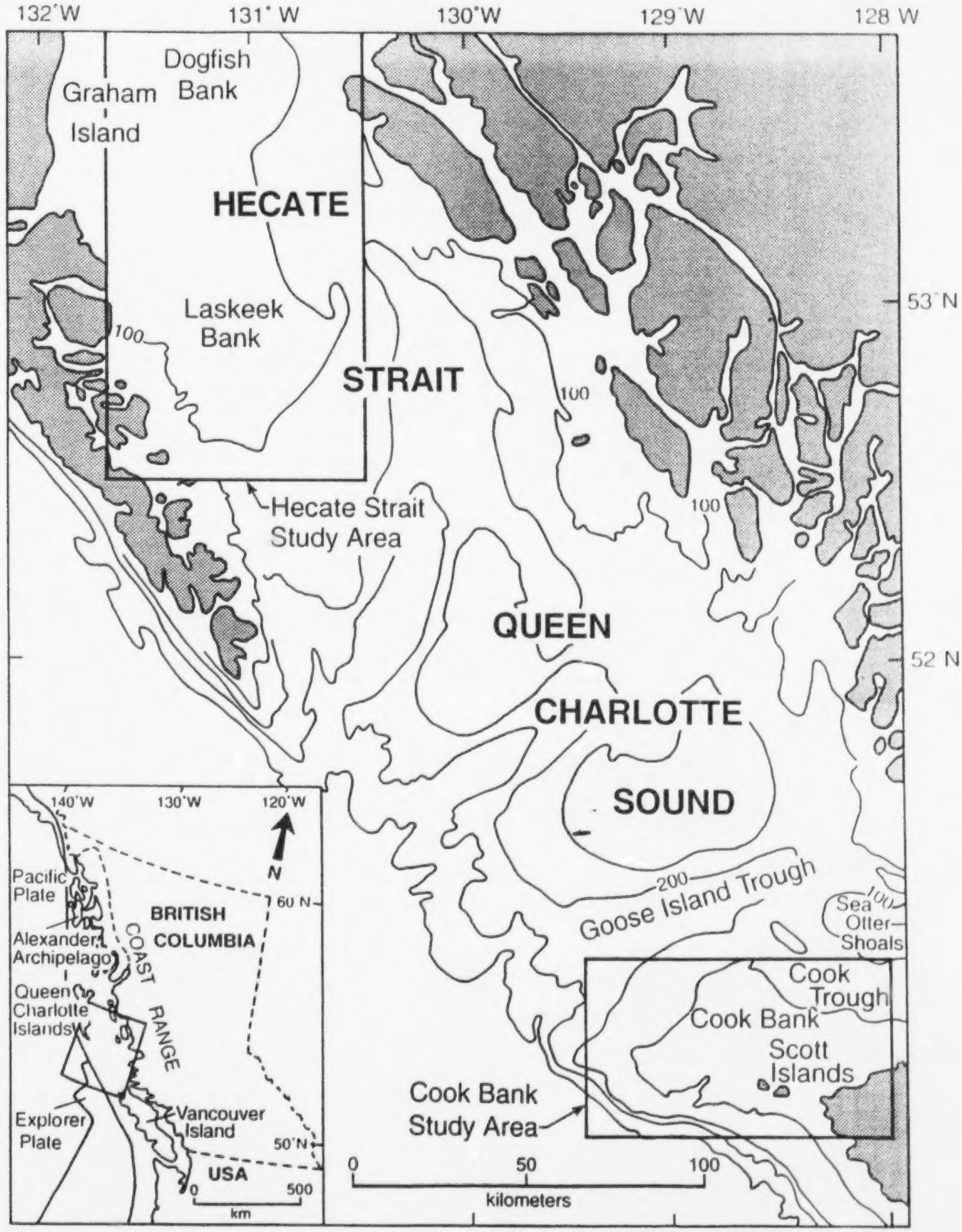

132°W
131° W
130°W
129°W
128 W
53°N
52 N
Graham Island
Dogfish Bank
HECATE
Laskeek Bank
100
STRAIT
100
100
Hecate Strait Study Area
QUEEN
CHARLOTTE
SOUND
200
Goose Island Trough
Sea Otter Shoals
100
Cook Trough
Cook Bank
Scott Islands
Cook Bank Study Area
0
50
100
kilometers
140°W
130°W
120°W
N
Pacific Plate
60 N
BRITISH COLUMBIA
COAST RANGE
Alexander Archipelago
Queen Charlotte Islands
Explorer Plate
Vancouver Island
50°N
USA
0
500
km

Figure 2. Location of the study areas.

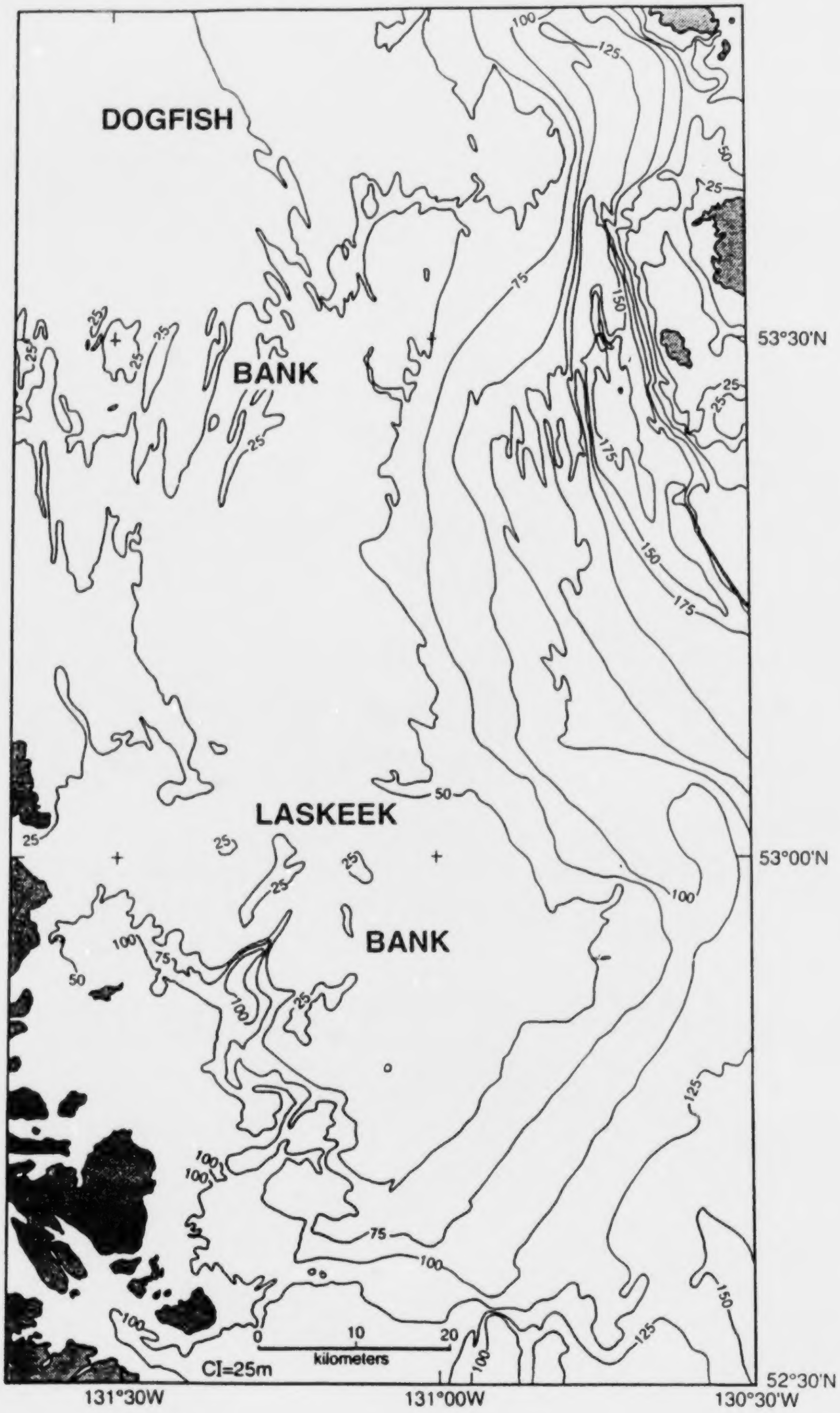

DOGFISH
BANK
LASKEEK
BANK
CI=25m
0
10
20
kilometers
53°30'N
53°00'N
52°30'N
131°30'W
131°00'W
130°30'W
25
50
75
100
125
150
175

Figure 3. Bathymetric map of Hecate Strait study area (Figure 2).

(Sutherland-Brown, 1968). The parts of South Moresby Island nearest the study area are also predominantly underlain by sedimentary and volcanic rocks, although plutonics, particularly diorites, are common on much of the island. To the east, the Coast Range is principally composed of granitic to dioritic plutonic rocks and amphibolite-grade metamorphics (Gottesfeld, 1985).

On the western side of the strait, the Late Wisconsinan glaciation on Graham Island appears to have been of limited extent and duration, as Cape Ball on eastern Graham Island was ice-free at 18000 BP (Warner et al., 1982), and the ice had retreated from northern Graham Island by 16000 BP (Clague et al., 1982). Between 13500 BP and 9000 BP, sea levels may have fallen to 95m below modern levels (Barrie and Bornhold, 1989), in contrast to the isostatically depressed mainland coast where relative sea levels were as much as 200m higher than present (Clague et al., 1982). This period of exposure in the western part of the strait resulted in significant erosion, exposing bedrock in much of the area above the 100m isobath (Barrie and Bornhold, 1989). Fluvial channels, typically 5-30 m deep and 200-1000m wide were incised into Tertiary bedrock at this time. After this low stand, relative sea level rose to a maximum of 15m above modern sea levels on Graham Island from 8500 to 7500 BP (Figure 4a; Clague et al., 1982), then gradually regressed, leaving raised shorelines on eastern Graham Island. The uneven Tertiary surface on the banks has

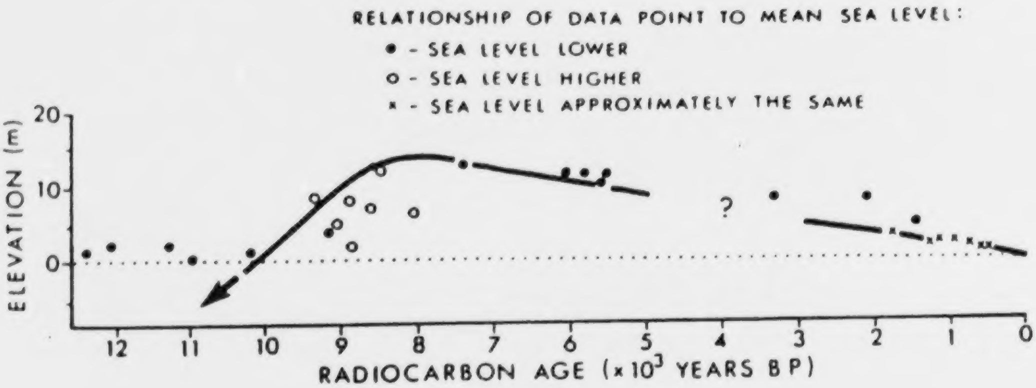


Figure 4a. Relative sea-level curve for Graham Island and western Hecate Strait. Modified from Clague et al., 1982.

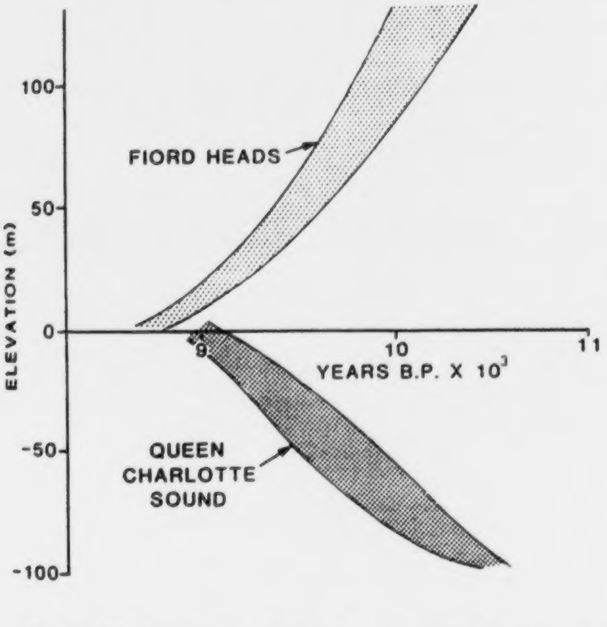


Figure 4b. Relative sea level curves for Queen Charlotte Sound and mainland fjords. Modified from Luternauer et al., 1989.

been infilled with a thin (<3m thick) deposit of Quaternary sands and gravels, creating a relatively flat seabed (Barrie, 1988).

Sea surface temperatures in Hecate Strait and Queen Charlotte Sound range from approximately 6°C in April, to 14°C in August (Thomson, 1981). Water circulation in the strait is intense, and is controlled by the semi-diurnal tidal currents and wind-driven currents. The tidal currents are rectilinear, oriented northwest to southeast or northeast to southwest, and are strong enough to transport sediment even in water depths greater than 100m (Barrie and Bornhold, 1989). Although somewhat protected from the open ocean by the Queen Charlotte Islands, large swells can approach the area from the south. During the period from September to November, the maximum significant wave height is 8m in central Hecate Strait (Canadian Hydrographic Service, 1991). Wind-driven currents flow strongly to the north in fall and winter, but are weak and erratic in summer (Crawford et al., 1988). At a water depth of 40m in central Hecate Strait, currents exceeded 35 cm/s more than 10% of the time over a 131 day period (Pacific Geoscience Center Data File, 1989).

B. Cook Bank

The Cook Bank site, previously documented by Nelson and Bornhold (1983), is located between 50°40' and 51°10'N, and between 128°00' and 130°30' W, an area of approximately 6000 km^2 (Figure 5). The central part of this area is underlain by Mesozoic volcanic, plutonic and sedimentary rocks which extend in a belt from the northwest corner of Vancouver Island through the Scott Islands. The topography in this region is extremely rugged, with local relief commonly up to 40 m (Bornhold and Yorath, 1984). To the south are flat-lying sedimentary rocks, where the seafloor slopes gently southwest until the shelf/slope break at a water depth of approximately 200m. To the north, Cook Bank extends as a wide platform to a depth of 100m in Queen Charlotte Sound where it is terminated by Cook Trough.

Late Wisconsinan ice had retreated from Queen Charlotte Sound by 15000 BP (Luternauer, 1986), and Cook Bank was subsequently exposed to a water depth of approximately 100 m. In a core taken at a depth of 95m on Cook Bank, this period of exposure is represented by a paleosol. During this time, the sea floor shallower than 100m was stripped of sediment except in fluvial channels. The low stand was followed by a transgression in the early Holocene, and by regression in the past 5000 to 6000 years (Luternauer and Murray, 1983). This sea level history is remarkably similar to that of Hecate Strait. Both areas experienced subaerial erosion during a late Pleistocene low stand, when the mainland coast was still submerged (Figure 4b), because glacial ice thinned abruptly from the mainland, resulting in much less isostatic depression than on the mainland coast (Luternauer et al., 1989). Both

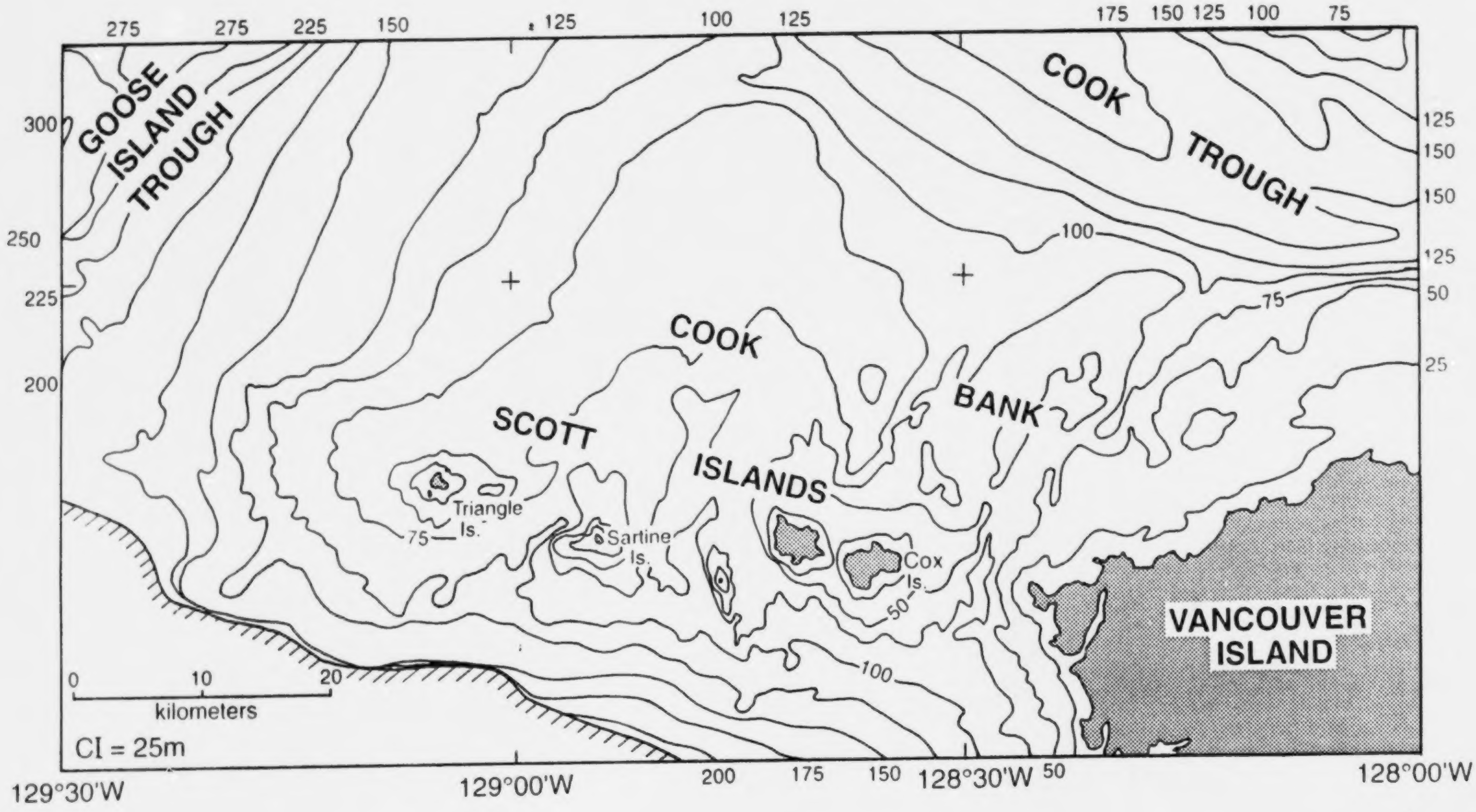

275
275
225
150
125
100
125
175
150
125
100
75
GOOSE ISLAND TROUGH
COOK TROUGH
300
250
225
200
125
150
150
125
50
25
100
75
COOK
SCOTT
BANK
ISLANDS
Triangle Is.
75
Sartine Is.
Cox Is.
50
100
VANCOUVER ISLAND
0
10
20
kilometers
CI = 25m
129°30'W
129°00'W
200
175
150
128°30'W
50
128°00'W

Figure 5. Bathymetric map of the Cook Bank study area (Figure 2).

areas were then submerged by an early Holocene transgression. Finally, there is evidence from both areas of coastal emergence following a mid-Holocene high stand in sea level. This similarity in post-glacial sea level history, matched by a similarity in sediment types, suggests that the post-glacial history may have influenced the development of carbonate sediments in these areas.

Oceanographic conditions on Cook Bank are extremely energetic. Surface tidal currents can exceed 150 cm/s in passages between the Scott Islands (Canadian Hydrographic Service, 1976), and the dominant currents trend southwest to northeast. Bottom currents of 62 cm/s have been measured at water depths of 75 m (Barber, 1957), and currents of 39 cm/s at depths of 110m (Luternauer, 1986). The area is subject to more intense wave action than Hecate Strait, particularly when waves approach from the open Pacific to the southwest. The maximum significant wave height for the period from December to February northwest of Triangle Island is 11.4m (Canadian Hydrographic Service, 1991) and waves as high as 30.5 m have been reported when ebbing currents oppose storm waves (Thomson, 1981).

III. METHODS AND DATA BASE

A. Field Methods

1. Surficial Samples

Grab samples were collected between 1976 and 1987 by the Pacific Biological Station (P.B.S.) and the Geological Survey of Canada, Sidney (G.S.C.) using a Shipek grab sampler. The samples obtained are typically about 20 cm x 20 cm, with a maximum depth of about 10 cm (Conway, 1987). The locations for grab samples from Hecate Strait and Cook Bank are shown in Figures 6 and 7 respectively. Data from the following cruises were used.

Table I. Cruises Providing Data for the Study

Ship	Year	Cruise	Collector	Area
CSS. Parizeau	1976		G.S.C.	Cook Bank
MV Pandora II	1977		G.S.C.	Cook Bank
GB Reed	1978	A	P.B.S.	Hecate Strait
GB Reed	1978	B	P.B.S.	Hecate Strait
MV Pandora II	1978		G.S.C.	Cook Bank
CSS Vector	1981	B	G.S.C.	Hecate Strait
CSS Endeavour	1983	B	G.S.C.	Cook Bank
CSS Parizeau	1983	A	G.S.C.	Hecate Strait
GB Reed	1983	A	P.B.S.	Hecate Strait
GB Reed	1984	A	P.B.S.	Hecate Strait
GB Reed	1985	A	P.B.S.	Hecate Strait
CSS Endeavour	1987	A	G.S.C.	Cook Bank

2. Cores

Core Samples were obtained using a submersible vibracorer operated by the Geological Survey of Canada, and capable of taking sand and gravel cores up to 3.3m in length. Four cores

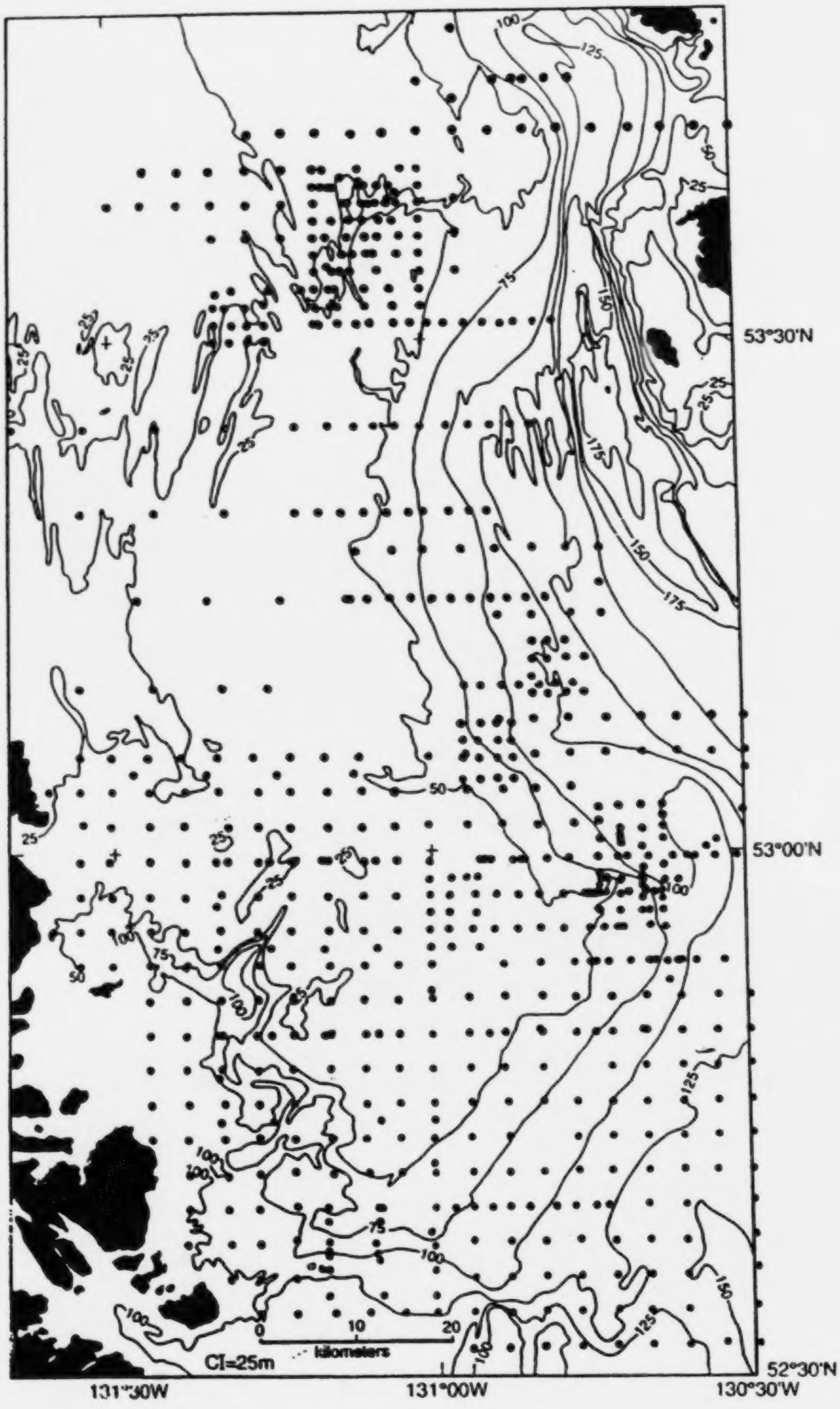

100
125
50
25
75
175
150
53°30'N
53°00'N
52°30'N
131°30W
131°00W
130°30'W
0
10
20
kilometers
CI=25m

Figure 6. Grab sample locations for Hecate Strait.

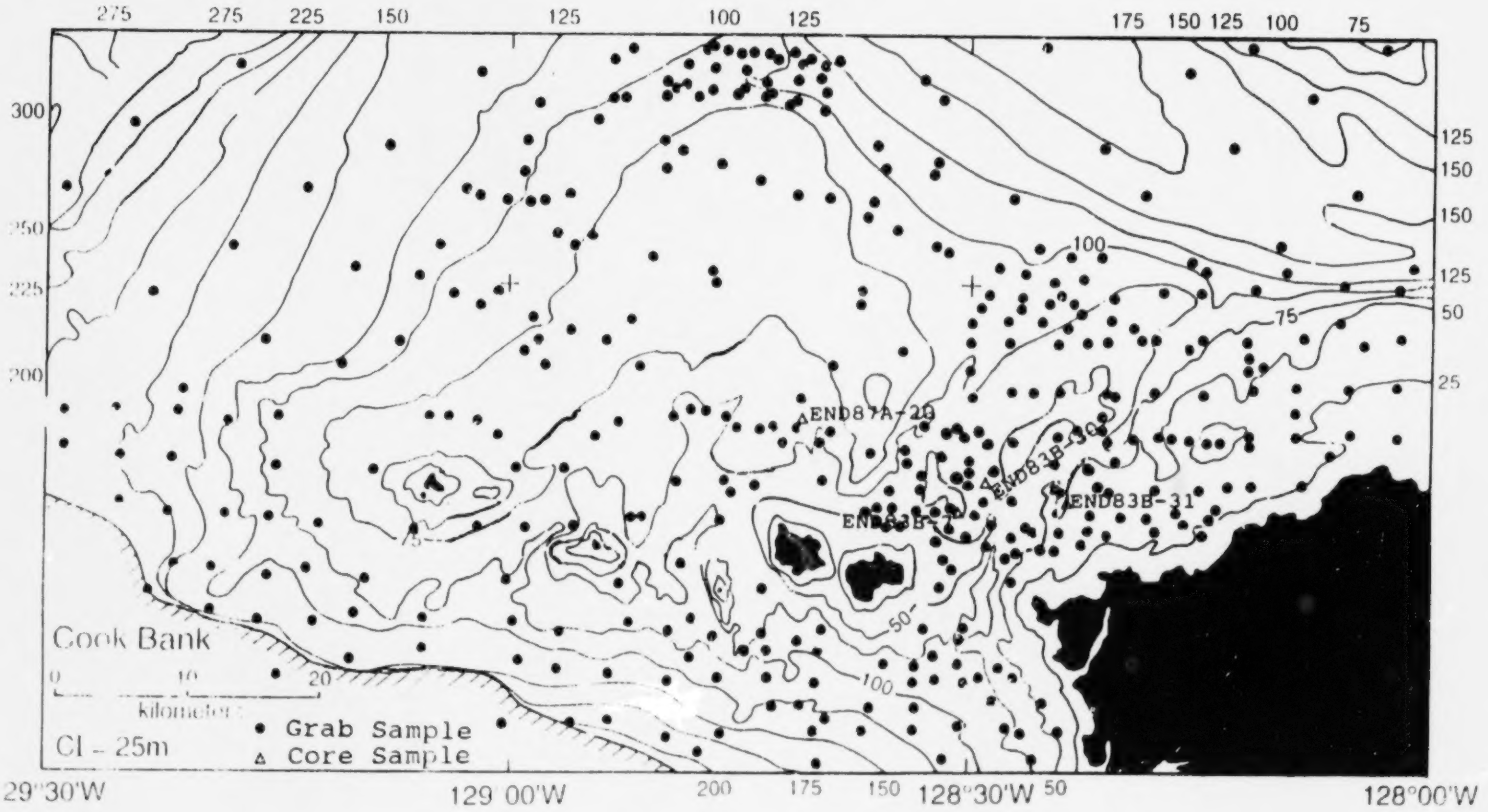

275
275
225
150
125
100
125
175
150
125
100
75
300
250
225
200
125
150
150
125
50
25
100
75
50
100
75
END87A-20
END83B-30
END83B-31
END83B-7
Cook Bank
0
10
20
kilometers
CI - 25m
● Grab Sample
▵ Core Sample
129°30'W
129°00'W
200
175
150
128°30'W
50
128°00'W

Figure 7. Grab sample and core locations for Cook Bank.

were used for in this study: END83B-7, END83B-30, END83B-31 and END87A-20 (Figure 7).

Three of the cores from Cook Bank examined were collected from areas where the surficial sediments are carbonate-rich. The fourth (END83B-30) was taken in a nearby area where carbonate material is a minor constituent of the sediment. The cores ranged from 30 cm to 195 cm in length.

3. Geophysical Data

Huntec Deep Tow Seismic high-resolution seismic profiles and 50 KHz sidescan sonar data were collected by the Geological Survey of Canada for both study areas. Geophysical data for Cook Bank was obtained on the CSS Endeavour, 1987 cruise. Data for Hecate Strait was obtained on the CSS Hudson and CSS Vector cruises in 1981, the MV Pandora II cruise in 1982, and the CSS Vector cruise in 1984. Geophysical lines for Hecate Strait are shown in Figure 8, and for Cook Bank in Figure 9.

B. Laboratory Methods

1. Analysis for Calcium Carbonate Content

The sand fractions of 665 samples from Hecate Strait and 166 samples from Cook Bank were analysed for calcium carbonate content. The carbonate contents for most samples collected prior to 1983 were obtained from Conway (1987) and from data on file at the Pacific Geoscience Center and those of other

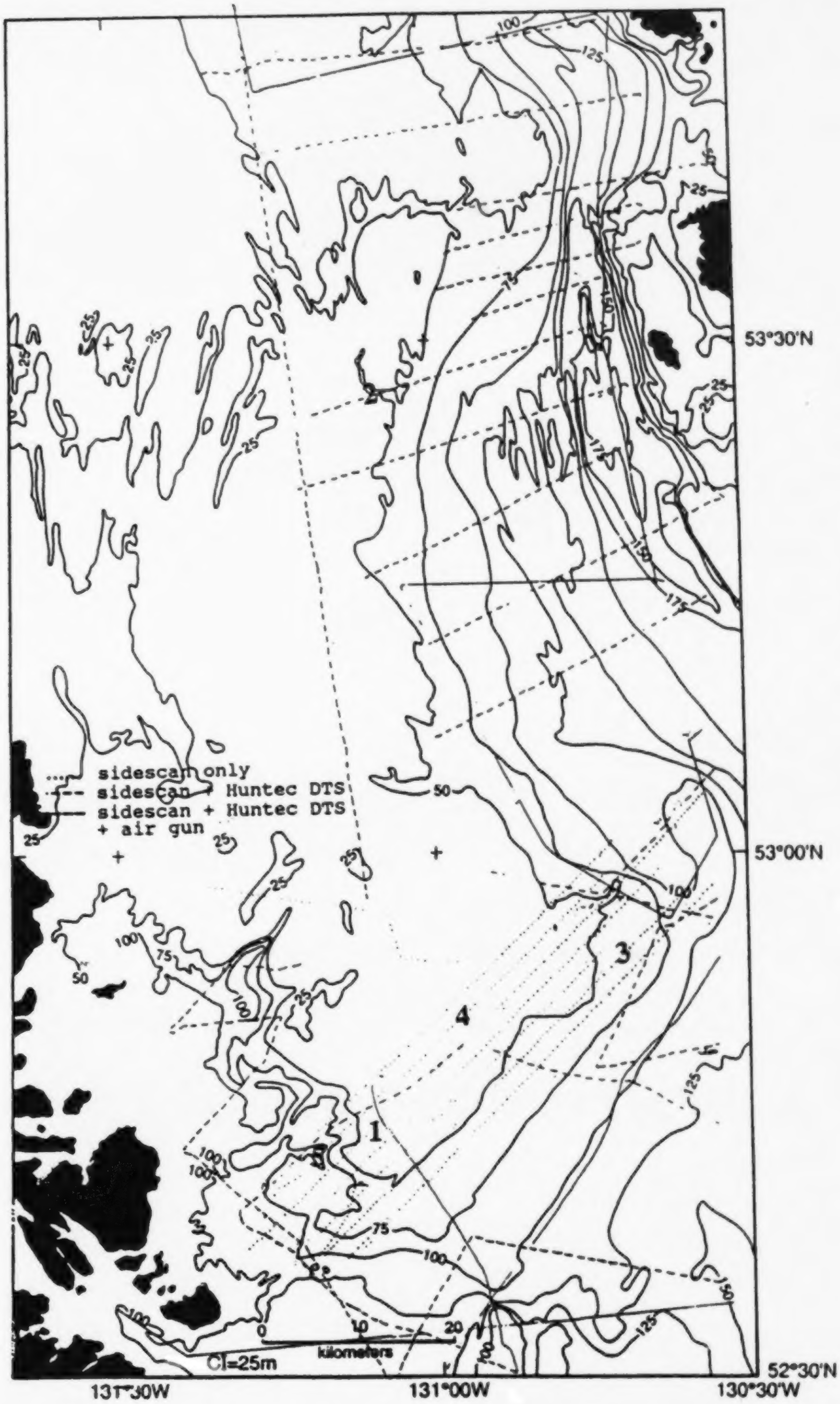

sidescan only
sidescan + Huntec DTS
sidescan + Huntec DTS + air gun
53°30'N
53°00'N
52°30'N
131°30'W
131°00'W
130°30'W
0
10
20
kilometers
CI=25m
1
3
4
25
50
75
100
125
150
175

Figure 8. Geophysical data for Hecate Strait. Numbers indicate locations of geophysical records shown in Figures 30, 31,32,33, and 34.

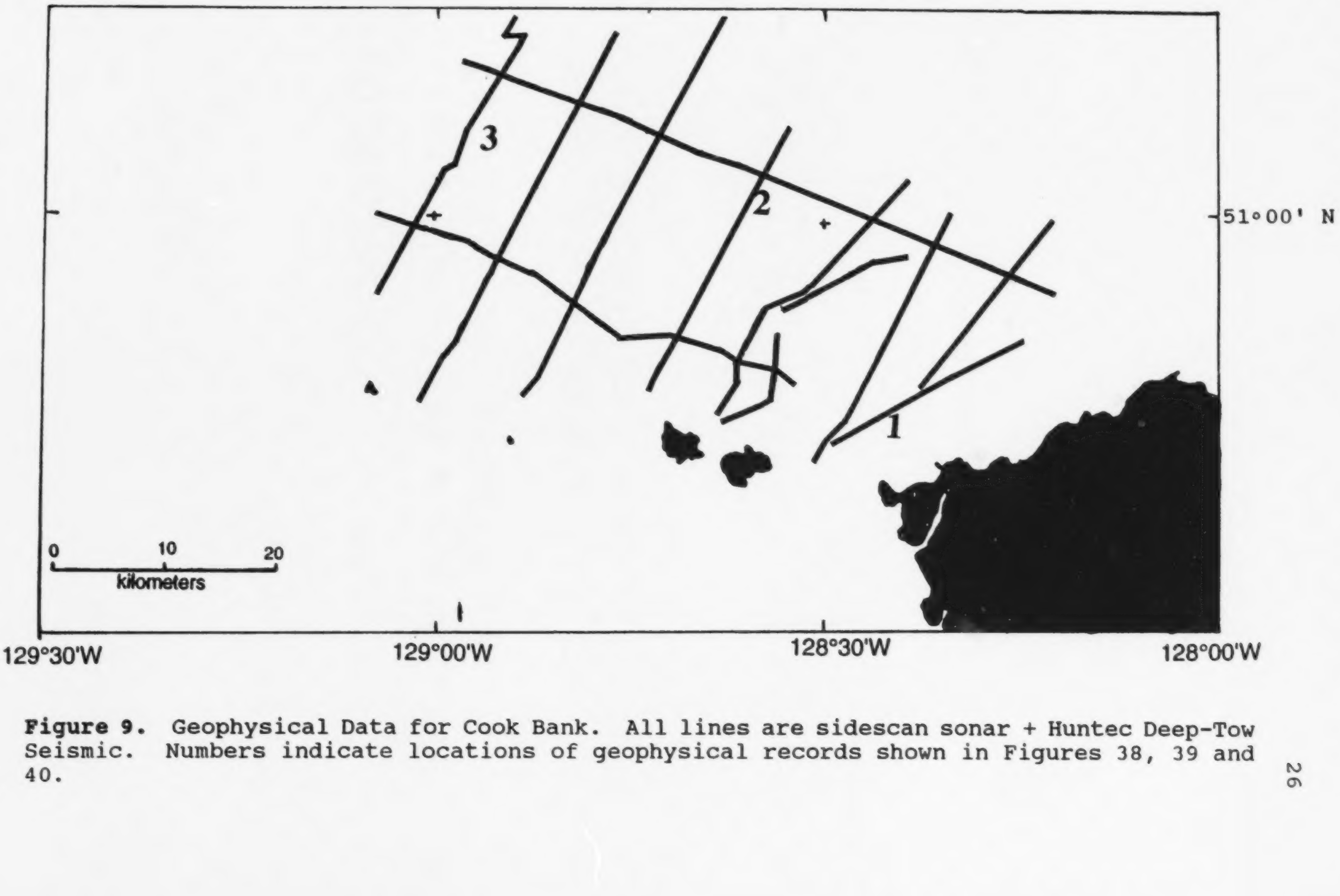

51°00' N
3
2
1
0
10
20
kilometers
129°30'W
129°00'W
128°30'W
128°00'W

Figure 9. Geophysical Data for Cook Bank. All lines are sidescan sonar + Huntec Deep-Tow Seismic. Numbers indicate locations of geophysical records shown in Figures 38, 39 and 40.

samples were determined by the author. All determinations made by leaching a sand subsample of approximately 20g with 2.0 M hydrochloric acid and measuring the weight lost after complete dissolution of the carbonate material.

Carbonate contents of the gravel fractions of selected samples were also determined, in order to compare the gravel contents of the terrigenous and carbonate components of the samples. Lee & Adkins (1978), and J.C. Lee & Associates (1982) included a visual estimate of the carbonate fraction of gravel samples in their faunal analysis reports. This data was combined with that from an additional 29 samples, which were separated into carbonate and terrigenous fractions and weighed by the author.

2. Grain Size Analysis

The grain size data quoted in this study are taken from Conway (1987) for Hecate Strait, and from the Pacific Geoscience Center Data Base for Cook Bank. Grain size was determined by first separating the gravel, sand and mud fractions by seiving. The resulting fractions were then analysed using seives, the Pacific Geoscience Centre settling tube, and a Sedigraph 5000D for the gravel, sand and mud fractions respectively (Conway, 1987). The sediment textures were classified using a modified Folk classification (Figure 10).

3. Pebble Lithologies

Pebble lithologies were determined for 36 samples from the northern part (north of 53°05'N) of the Hecate Strait study area. This area was chosen as it contains important transitions in calcium carbonate content and grain size. Where available, a minimum of fifty pebbles in the -2 to -6ø size fraction were randomly selected for lithologic analysis. If fewer than fifty pebbles of that size were available, granules from the -1 to -2ø size fraction were also counted. The pebbles were divided into five lithological groups: plutonic rocks, volcanic rocks, sedimentary rocks, quartz, and miscellaneous. For the purposes of a ternary diagram, the sedimentary and volcanic rocks were combined, because they are likely derived from the local bedrock or from the Queen Charlotte Islands. The Plutonic rocks and quartz pebbles were combined, because they are probably derived from the Coast Range. The third axis of the ternary diagram was the proportion of miscellaneous rocks.

A Q-mode cluster analysis was performed on the data, based on a euclidean distance coefficient. Two forms of clustering were used: a single linkage clustering and a complete linkage clustering. Clustering methodology is discussed in Appendix III.

4. Faunal identification

Faunal identifications were determined for 51 samples

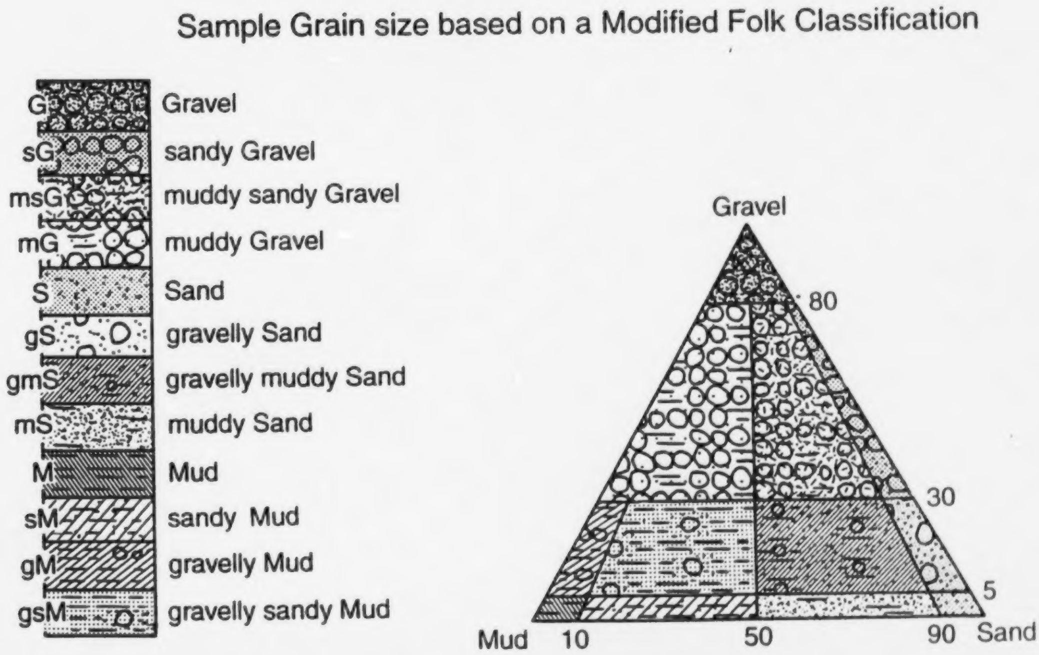

Sample Grain size based on a Modified Folk Classification
G Gravel
sG sandy Gravel
msG muddy sandy Gravel
mG muddy Gravel
S Sand
gS gravelly Sand
gmS gravelly muddy Sand
mS muddy Sand
M Mud
sM sandy Mud
gM gravelly Mud
gsM gravelly sandy Mud
Gravel
80
30
5
Mud
10
50
90
Sand

Figure 10. Sediment texture classification. Modified from Folk (1962); Barrie and Bornhold (1989).

from Cook Bank by Lee & Adkins Ltd. (1978), and for 50 samples from Hecate Strait by J.C. Lee & Associates (1982). The samples containing the most abundant calcareous material appear to have been selected. Molluscs, Brachiopods and Coelenterates were identified to species level (where possible), and their relative abundances noted. The abundance of other taxa was also noted, but they were not identified beyond phylum.

Mollusks from an additional thirty-seven samples from Hecate Strait were identified by the author, with the aid of Dr. R. Palmer and Mr. J. Van Es of the Department of Zoology, University of Alberta. Organisms were identified primarily through the keys of Kozloff (1987), in combination with Keen (1963), Bernard (1970) and Abbott (1974). Species were assigned an abundance class from 0 to 6 (Table 2).

Table 2. Abundance Classes for Faunal Data

Abundance Class	Number of Individuals	Percentage of Specimens	J.C. Lee and Associates
0	0	0	
1	> 0	> 0	rare
2	> 1	> 1	scarce
3	> 2	> 5	present
4	> 4	> 10	common
5	> 12	> 25	abundant
6	> 25	> 50	very abundant

Species found in the samples were classified as either hard-substrate (rock or gravel), soft-substrate (sand or mud) dwellers based on ecological information from Abbott (1974) and Kozloff (1988). Other species which may live in sands or gravels, comprised a third category. A Substrate Index was calculated based on the relative abundance of hard and soft substrate faunas (Appendix C).

In a similar fashion species were classified as shallow water (predominantly <50 m), deep water (>50m), or as species living in both settings, based primarily on Bernard (1970). A Shallowness Index was calculated based on the relative abundance of shallow and deep water faunas (Appendix C).

A Q-mode cluster analysis was performed on the data. The coefficients of similarity between samples were determined using the Kulczynski (1928) formula. The data was then clustered using a complete linkage clustering method (Legendre and Legendre, 1983).

5. Scanning Electron Microscope

Ten samples were examined with a scanning electron microscope (SEM) to determine the effects of boring, physical abrasion, and dissolution on shell material. Five of the samples were from a variety of water depths and substrates in Hecate Strait, and five samples were from intervals in Core END83B-07 on Cook Bank (Table III).

The samples were prepared by taking a random subsample of the carbonate gravel fraction of the sample, and break it into fragments with a mortar and pestle. This subsample was mixed, and a mount covered with wet silver paint was pressed into it, and the fragments which adhered to the mount were examined with a scanning electron microscope.

Table III. Samples examined under SEM

Sample			Location Description
1.	Core -	END83B-07	Mixed sample from 0-10 cm in massive shell hash
2.	"	"	Stained Glycymeris valves from 32-34 cm in whole-shell layer
3.	"	"	Shell fragments from 43-45 cm in sandy layer
4.	"	"	Mixed sample from 75-82 cm in massive shell hash
5.	"	"	Mixed sample from 100-102 cm in massive shell hash
6.	Grab	GBR83A-08	Tellina fragments from sands at 29m on Dogfish Bank
7.	"	GBR83A-23	Glycymeris fragments from gravels at 27m on western Laskeek Bank
8.	"	VEC81B-65	Glycymeris fragments from sands at 73m on Laskeek Bank
9.	"	VEC81B-169	Mixed fragments from muddy sandy gravel at 190m in western Hecate St.
10.	"	GBR84A-182	Mixed fragments from muddy sand at 135m in southern Hecate St.

6. Radiocarbon Dating

Five surficial samples used in this study from Hecate Strait were radiocarbon dated and Carbon-13 corrected by Krueger Enterprises, Inc., Cambridge, MA, USA in 1981 (Bornhold, pers. comm., 1990), and four samples from Cook Bank were dated by the University of Waikato in 1982 (Nelson and Bornhold, 1983).

Three further radiocarbon dates were obtained from Beta Analytic, Miami, FL, USA. Two of these were from shells near the surface of Cook Bank cores, and a third from a sample of Tellina nuculoides shells in Hecate Strait. All samples were prepared for processing by physical abrasion and etching with acid solutions. Further acid was used to generate the carbon dioxide, which was synthesized to benzene, and given quadruple-normal counting time, to reduce error. A fresh Glycymeris subobsoleta shell from a depth of 118 cm in a core from was dated using accelerator mass spectrometry. This sample was prepared for measurement as above by Beta Analytic, and the AMS measurements were made in triplicate at the Eidgenossische Technische Hoschschule, Zurich, Switzerland. The resulting date was C-13 corrected.

7. Contouring Philosophy

One problem which arose in mapping the grab sample data was extreme local variations in sediment composition. In those cases where one sample deviated strongly from the local pattern, it was ignored for the purpose of contouring, although the anomalous sample was annotated on the maps.

Another difficulty was the uneven distribution of sample sites. In areas where there was very limited data, the contours were generally interpolated to display similar patterns to the areas of dense sampling. For example, if the quantity being contoured mimicked the bathymetry in densely sampled areas, it was assumed to do so in areas of limited sampling, if possible.

8. Core Description

The cores were described in detail and photographed in overlapping 30 cm intervals. They were divided into sedimentary facies on the basis of variations in grain size, sedimentary structures and lithology.

IV. RESULTS

A. Hecate Strait

1. Distribution of Calcium Carbonate

Complete sample data on calcium carbonate percentages are found in Appendix A. The carbonate percentage of the gravel fraction was determined for 74 samples. These data were used in combination with the carbonate content of the sand fraction to determine the total carbonate content of the samples. Carbonate contents of the sand and mud fractions were assumed to be equal. This assumption can be made without greatly biasing the results because the mud fraction for most samples is small (<5%),. Although many samples are largely composed of gravel, there is a strong positive linear correlation (r=0.86) between the carbonate content of the sand fraction and total carbonate content (Figure 11).

Figure 12 shows the distribution of calcium carbonate content in the sand fraction in Hecate Strait. Local sample variation is considerable: for example, samples VEC81B-14a and VEC81B-14b were both collected at 52 44.0'N, 131 00.0'W, yet contain 16.5% and 64.6% calcium carbonate respectively. Thus, the isolith contours cannot be used to accurately predict the composition of sediment at a particular locale.

Despite local anomalies, a pattern can be clearly seen. South of 53°10' N, the carbonate contours tend to mimic the bathymetry, particularly along the steep southwestern flank of Laskeek Bank. Nearly all samples taken from water

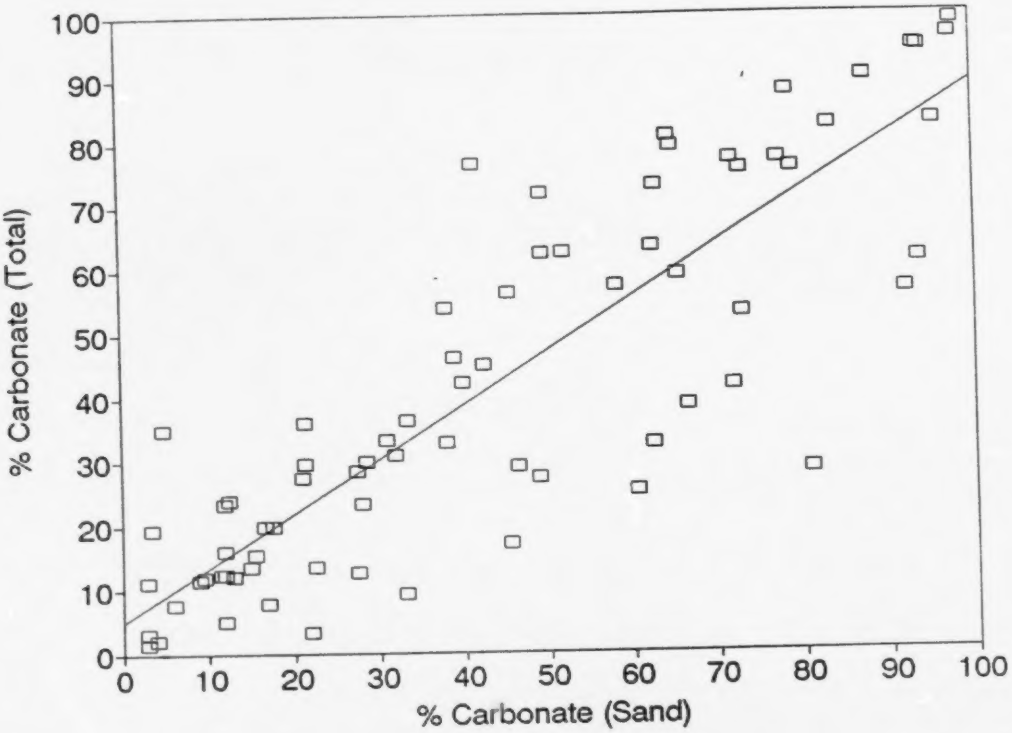


Figure 11. A plot of the carbonate content of the sand fraction vs. the total carbonate content of the sample for 74 samples from Hecate Strait and the line of best fit (r=.90).

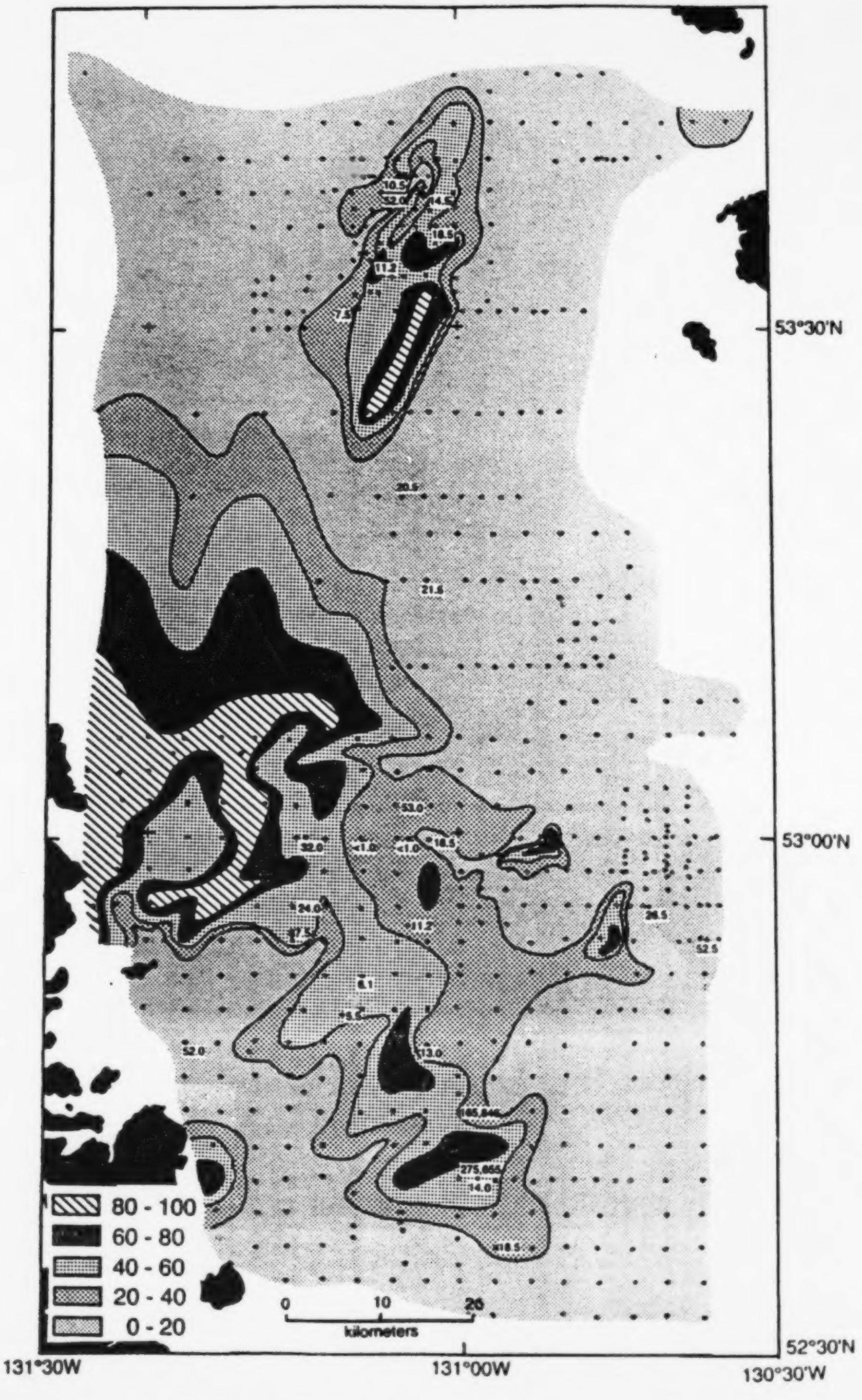

10.5
52.0
14.5
18.5
11.2
7.5
20.5
21.5
53.0
32.0
<1.0
<1.0
18.5
24.0
17.5
11.2
26.5
52.5
6.1
5.5
52.0
13.0
165,846
275,665
14.0
18.5
80 - 100
60 - 80
40 - 60
20 - 40
0 - 20
0
10
20
kilometers
53°30'N
53°00'N
52°30'N
131°30W
131°00W
130°30'W

Figure 12. Distribution of calcium carbonate in Hecate Strait. Values shown are local anomalies.

depths of greater than 100m have carbonate contents of less than 5%. In water depths of less than 50m the carbonate content is above 20% nearly everywhere, and greater than 60% on most of Laskeek Bank. Carbonate contents decline sharply along the southwestern flank of Laskeek Bank, and more gradually to the east and south. In similar water depths, carbonate contents are slightly lower on the eastern part of Laskeek Bank than on the western part.

North of 53°10'N, however, variability in carbonate content does not appear to be related to bathymetry. In water depths of less than 30m, the carbonate content gradually declines from over 80% at 53°00.0' to less than 20% north of 53°30'N. The northern half of the study area is strikingly barren of carbonate, with the exception of an elongate carbonate-rich zone which extends from north to south along the eastern edge of Dogfish Bank. In this zone carbonate contents locally exceed 80%.

2. Grain Size

Mean grain size, sorting and the relative proportions of the sand, gravel and mud fractions for samples in the study area are found in Appendix A. Many of the grab samples from Hecate Strait are multimodal and poorly sorted. Thus, the mean grain size and sorting, which are statistics designed to describe normal distributions, do not adequately describe these sediments. Local variation in gravel contents is considerable, much as it is in carbonate contents. An extreme example is the difference in gravel content between samples VEC81B-125a (10.2% gravel) and VEC81B-125b (76.6% gravel), samples taken at essentially the same location.

Figure 13 shows the distribution of sediment textures in the study area. A striking feature of the sediments is the predominance of sand and gravel in water depths of less than 100m. Mud contents are rarely greater than 3% in these areas. Despite the extreme local disparities in sediment texture, a distinct regional pattern does emerge.

The regional distribution of gravel contents is remarkably similar to the distribution of carbonate content (Figure 12). In southern Hecate strait, sediments in the shallow water areas are predominantly gravels and sandy gravels. However, north of 53° N, much of the shallow water region is dominated by sands and gravelly sands, which are low in carbonate content. The high carbonate zone on the eastern part of Dogfish Bank is also an area of gravels and sandy gravels.

Although gravel contents in individual samples show a poor correlation to carbonate content (Figure 14a), carbonate-rich samples are concentrated in areas where most samples are gravelly. This can be demonstrated by dividing the study area into 10' x 10' blocks and averaging the gravel and carbonate contents within each block (Appendix I). Those blocks containing less than 5 samples were ignored. The effect of

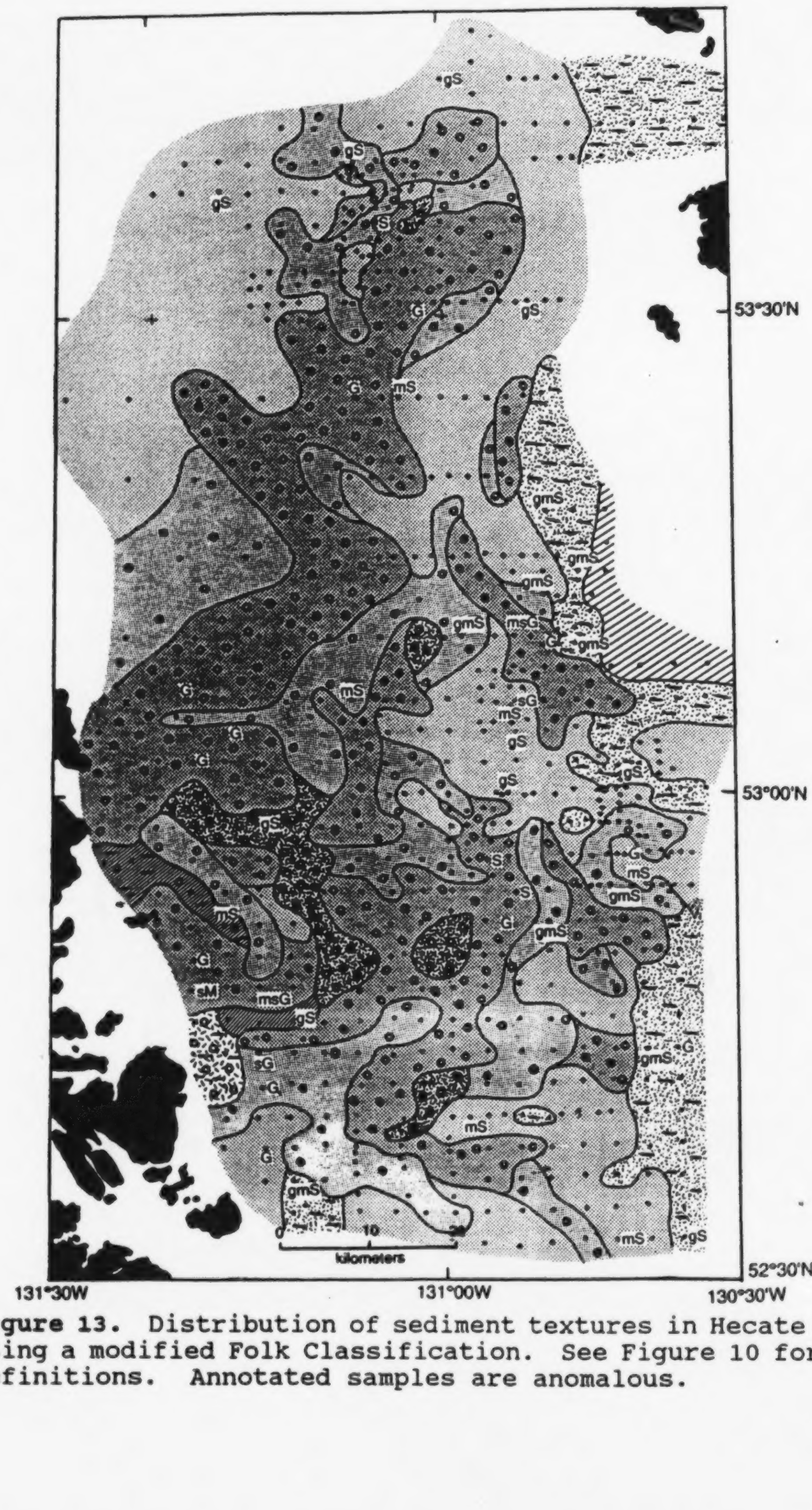

gS
gS
gS
S
G
gS
G
mS
gmS
gmS
gmS
gmS
msG
G
gmS
mS
sG
mS
gS
G
G
gS
gS
S
S
G
mS
gmS
G
mS
gmS
G
sM
msG
gS
sG
G
gmS
G
mS
G
gmS
mS
gS
0
10
20
kilometers
53°30'N
53°00'N
52°30'N
131°30W
131°00W
130°30'W

Figure 13. Distribution of sediment textures in Hecate Strait using a modified Folk Classification. See Figure 10 for class definitions. Annotated samples are anomalous.

this process is to give a picture of the regional pattern, and to eliminate bias in the results caused by sampling density. A strong positive linear relationship (r=0.82) exists between mean calcium carbonate content and mean gravel content for individual blocks (Figure 14b). This relationship holds most strongly in shallow water, but does not hold well in deep water where carbonate-rich samples are rare.

The relationship between sediment texture and carbonate content is so striking that it was hypothesized that it merely reflected a predominance of shell material in the gravel fraction, and relatively little terrigenous gravel in the region. However, if the size of the carbonate material accounted for this correlation, one would expect the carbonate contents in individual samples to correlate much more strongly with the gravel contents. Furthermore, when only the terrigenous fraction is considered, there is a strong positiive correlation (r=.90) between the gravel content of the terrigenous fraction and that of the whole sample (Figure 15a). Even when those samples containing less than 50% carbonate are eliminated, thereby discarding the samples where the terrigenous fraction could be expected to have the most impact on the total gravel content, this relationship remains clear (Figure 15b, r=.85). Thus, in those gravelly samples that are rich in both gravel and carbonate, the terrigenous component is predominantly gravel.

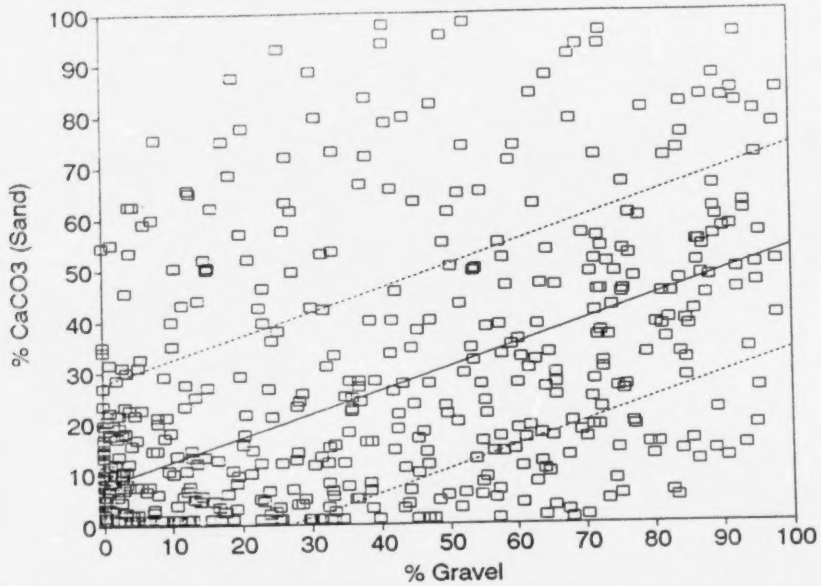


Figure 14a. Relationship between the size of the gravel fraction and carbonate content in 661 Hecate Strait samples. The solid line is the linear regression line, and the dashed lines are located one standard error away on either side of that line. r=0.58.

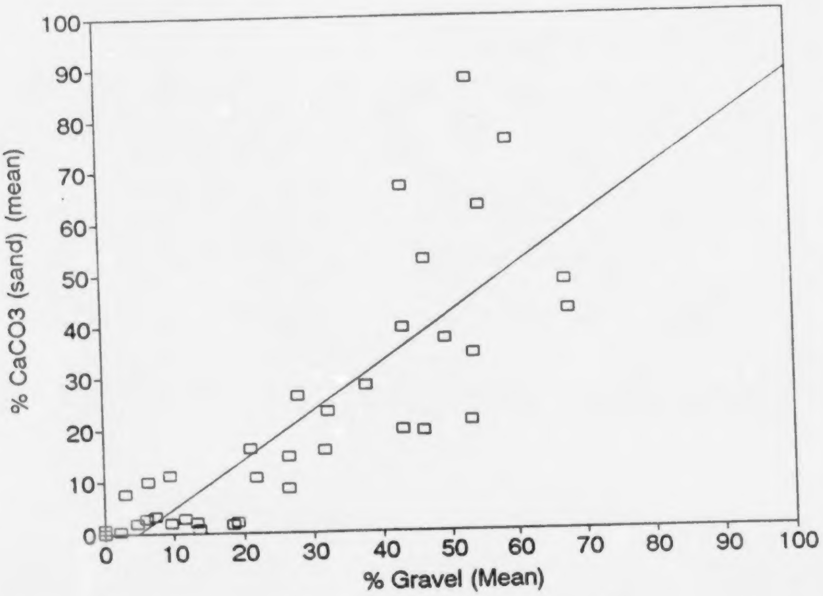


Figure 14b. Relationship between mean carbonate content and mean gravel content of samples in 10' x 10' blocks in Hecate Strait. 36 blocks containing more than 5 samples each are plotted, along with the regression line. r=0.82.

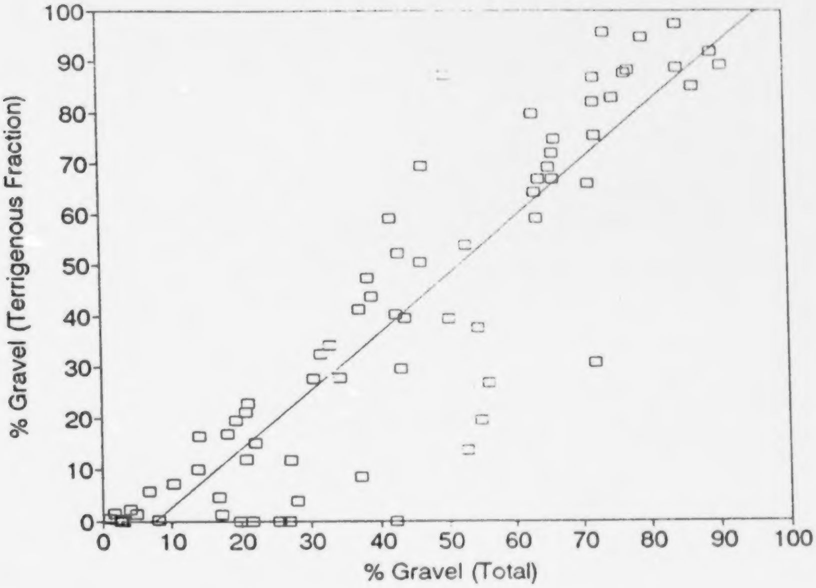


Figure 15a. Relationship between total gravel content and the gravel content of the terrigenous fraction for 74 samples from Hecate Strait. The linear regression line is shown. r=0.90.

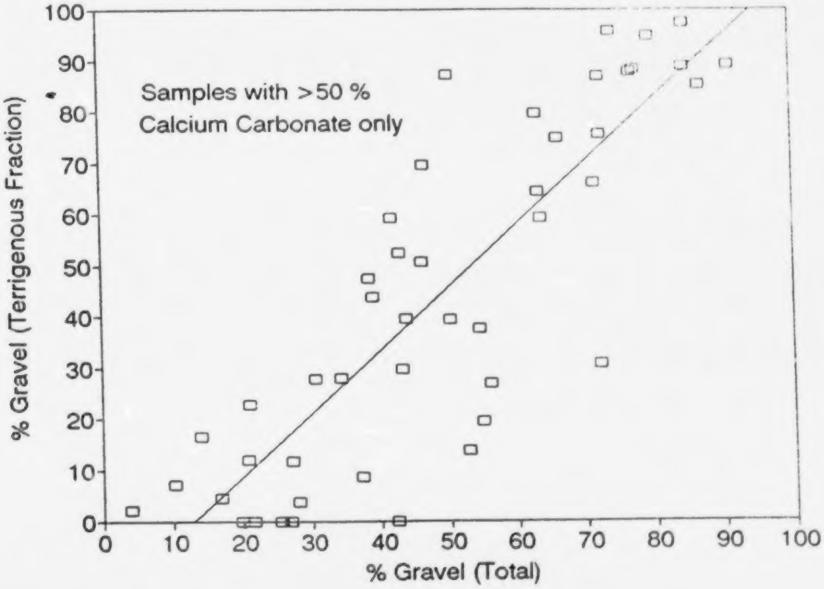


Figure 15b. As above, but considering only those 44 samples consisting of greater than 50% $CaCO_3$. r=0.85.

3. Pebble Lithologies

The complete pebble lithology determinations are found in Appendix B. Plutonic rocks are predominantly granite and syenite. Most of the recognizable volcanic rocks are of felsic to intermediate composition and porphyritic-aphanitic or tuffaceous texture. Sedimentary rocks are primarily lithic arenites and greywackes, and some dark grey siltstones. The miscellaneous rocks category contains metamorphic rocks, mafic mineral pebbles and fine-grained dark rocks which could include slates, fine-grained sedimentary rocks or basalts lacking clearly recognizable volcanic textures.

A ternary diagram of pebble lithologies, using plutonics + quartz, sedimentary + volcanics and miscellaneous as the three axes resulted in a diffuse, elongate cluster of points (Figure 16). The points are scattered along a line of roughly equal ratio of sedimentary and volcanic rocks to miscellaneous rocks, and increasing plutonic rocks (and minor quartz). No clear relationship could be established between carbonate content and location in this plot.

Because the primary variable seen in the triangle plot was the proportion of plutonic rocks, the plutonic rock percentage was mapped for the northern half of the study area (Figure 17). Plutonic pebbles are most abundant along the eastern edge of the banks, especially in the high carbonate zone on Dogfish Bank. The proportion of plutonic rocks in the sediment decreases both eastward into the deeper water and

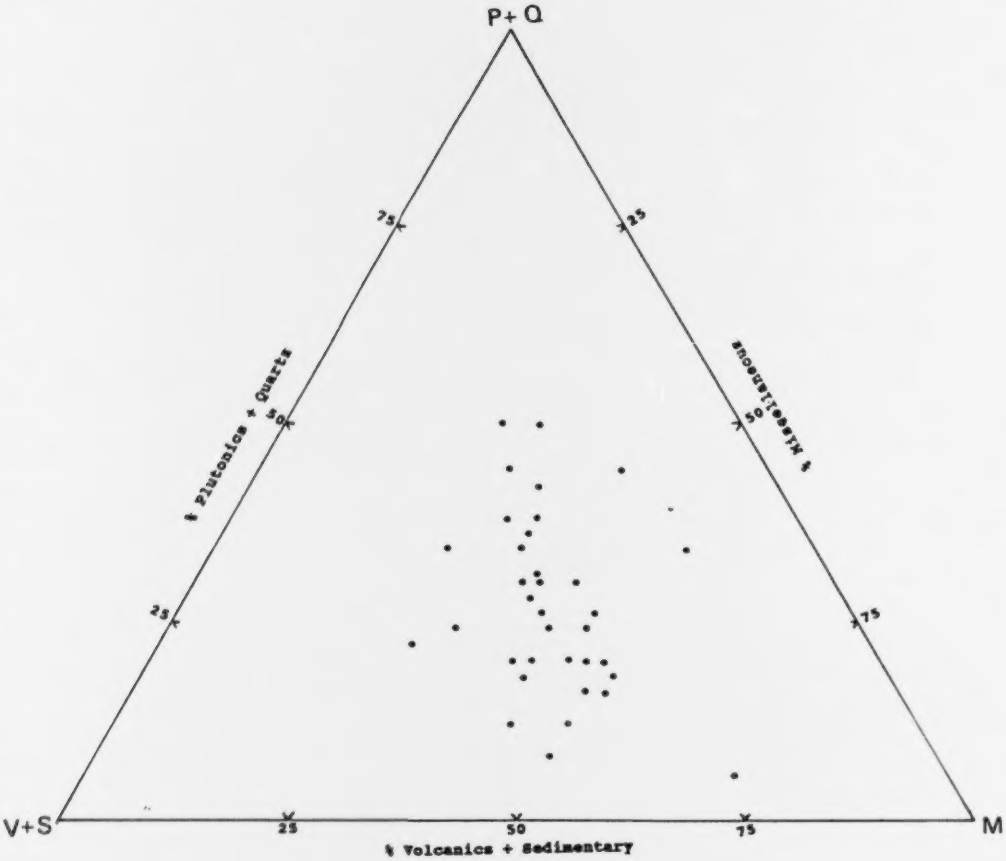


Figure 16. Ternary diagram of pebble lithologies for Hecate Strait. P = plutonics + quartz, S = sedimentary + volcanics, M= miscellaneous.

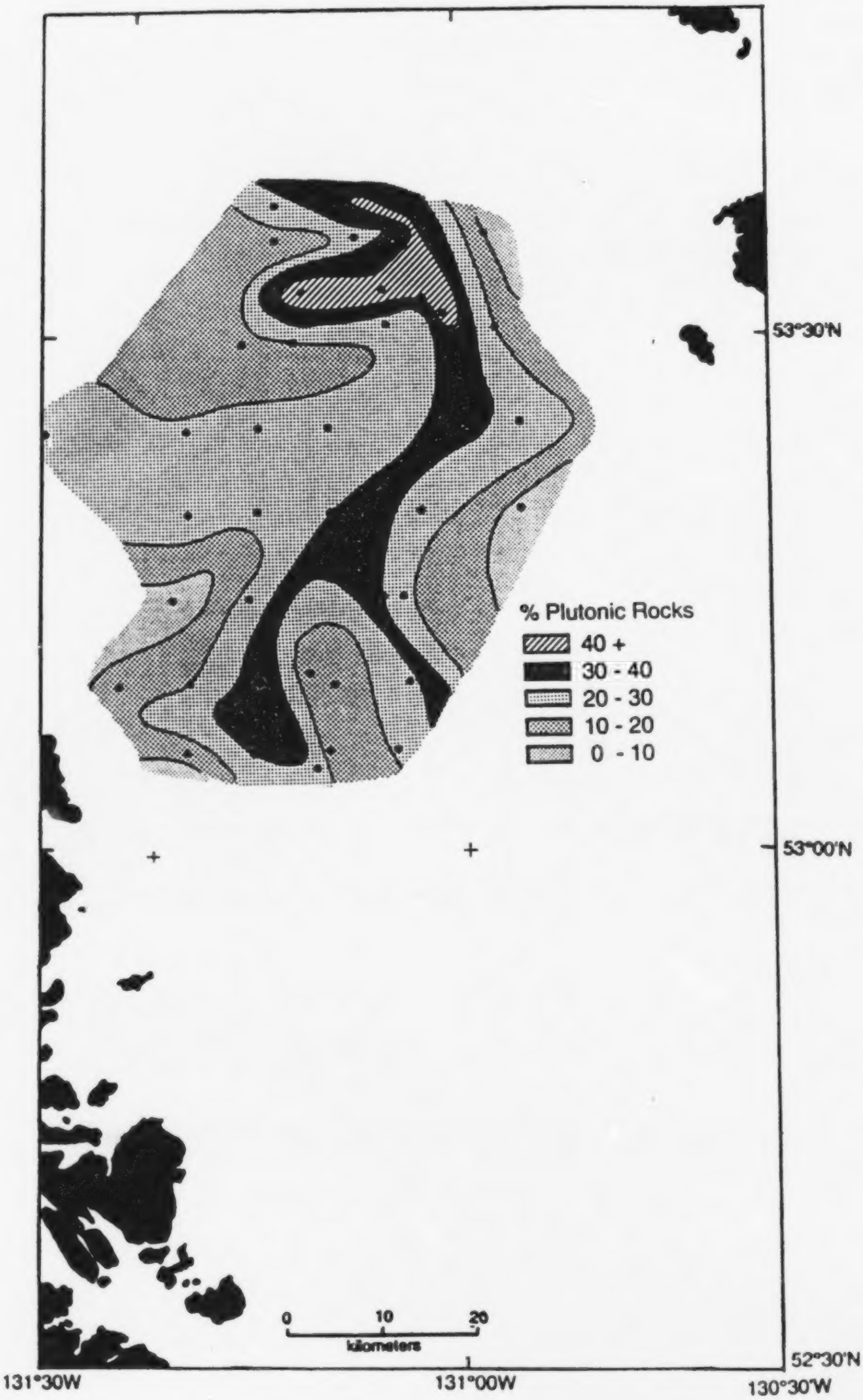

% Plutonic Rocks
40 +
30 - 40
20 - 30
10 - 20
0 - 10
53°30'N
53°00'N
52°30'N
131°30'W
131°00'W
130°30'W
0
10
20
kilometers

Figure 17. Plutonic pebble distribution in northern Hecate Strait.

westward toward the Queen Charlotte Islands. There is no clear relationship between the size of the plutonic component and either gravel percentage or carbonate percentage. The carbonate- and gravel-rich zone on eastern Dogfish Bank is a plutonic rich area, but other carbonate-rich areas farther south are poor in plutonic pebbles.

A disadvantage of single-linkage clustering is a tendency to "chain" the data into large elongate clusters in which end member samples may be very dissimilar (Legendre and Legendre, 1983). In this instance, the samples all end up joined together in one large cluster, adding one or two samples at a time.

A complete-linkage clustering gave more satisfactory results. An arbitrarily chosen criterion distance of 0.30 divided the samples into five classes (Figure 18). Classes I and II could be further subdivided into Ia, Ib, 2a, 2b, and 2c by choosing a lower dissimilarity cutoff.

Class I samples contain a moderate proportion of plutonic rocks (18-42%) and a relatively low proportion of miscellaneous rocks (26-42%). Class II samples are rich in miscellaneous rocks (40-52%), and have a low to moderate proportion of plutonics (10-26%). Class III samples are very rich in plutonic rocks (46%) and poor in miscellaneous rocks (24-28%). Class IV samples are similar to Class II, but contain a very low proportion of plutonics (4-6%). The lone sample belonging to Class V contains a very high proportion of

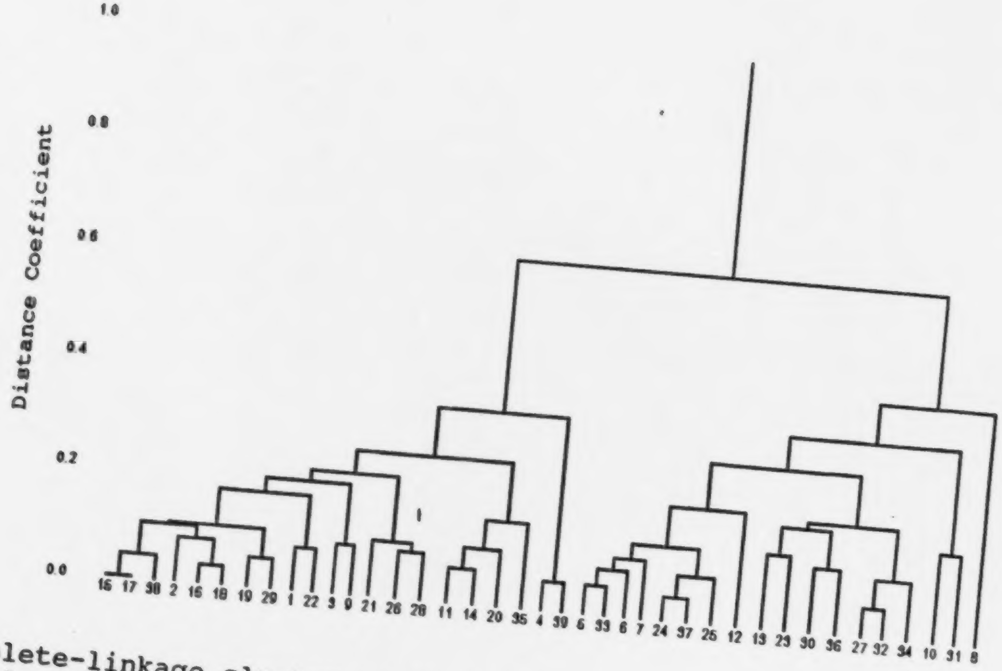


Figure 18. Complete-linkage cluster analysis of pebble lithologies in 39 Hecate Strait samples. A simple Pythagorean distance coefficient was used and an arbitrary value of 0.30 was chosen to break the data into five clusters.

miscellaneous rocks (71%), and is relatively poor in plutonic and sedimentary rocks. Otherwise the propoortion of sedimentary rocks varies little from class to class (14-30% in all samples).

Class I samples are most common through the central part of the map area, and in the northern part of the carbonate-rich zone on eastern Dogfish Bank (Figure 19). Class II samples are located in the deeper water, and in the shallow water both north and south of the Class I area. No clear conclusions can be drawn from the distributions of the three clusters with small numbers of samples. There is no clear correlation between either carbonate content or gravel content in the samples and the lithology class produced by the farthest-neighbour clustering.

4. Faunal Data

Thirty-eight species of bivalves and forty-five species of gastropods were identified in the eighty-seven samples. Complete species abundance data are found in Appendix IV. In seven samples, there was insufficient material (fewer than five identifiable individuals) to indicate the faunal composition at that locale, hence these samples are excluded from the faunal maps. Seventeen species were found to be common (abundance class >3) in at least one sample. These are:

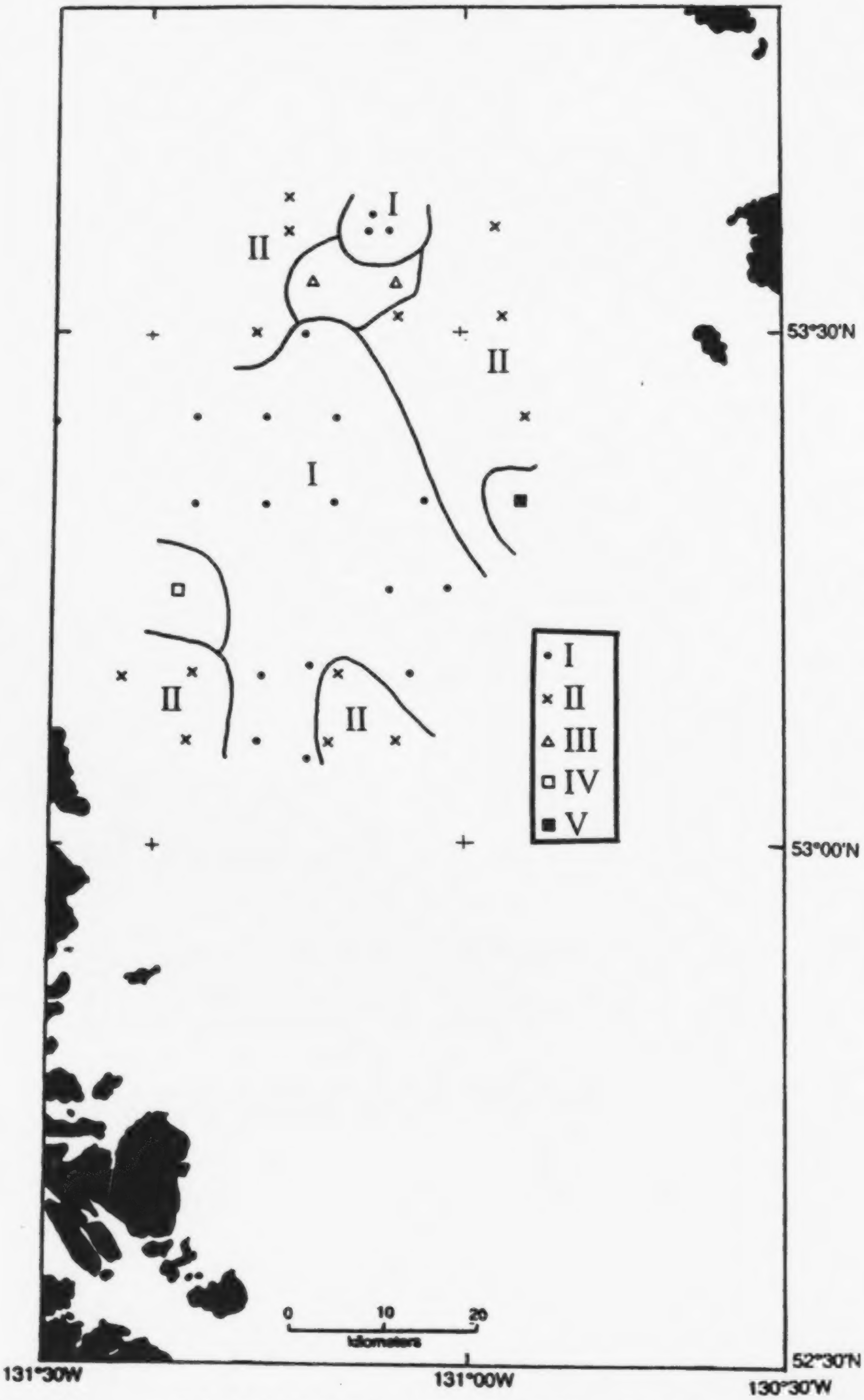

I
II
III
IV
V
53°30'N
53°00'N
52°30'N
131°30'W
131°00'W
130°30'W
0
10
20
kilometers

Figure 19. Distribution of pebble lithology classes determined by cluster analysis in Hecate Strait. See text for description of classes.

GASTROPODS

Homalopoma luridum (Dall, 1855)

Lepeta caeca (Muller, 1776)

Calyptraea fastigiata Gould, 1856

Crepidula dorsata (Broderip, 1834)

Crepidula nummaria Gould, 1846

Nucella emarginata (Deshayes, 1839)

Amphissa columbiana Dall, 1916

Olivella baetica Carpenter, 1864

BIVALVES

Glycymeris subobsoleta (Carpenter, 1864)

Chlamys rubida (Hinds, 1845)

Pododesmus cepio (Gray, 1850)

Miodontiscus prolongatus (Carpenter, 1864)

Cyclocardia ventricosa (Gould, 1850)

Tellina nucleoides (Reeve, 1854)

Protothaca staminea (Conrad, 1837)

Humilaria kennerlyi (Reeve, 1863)

Psephidia lordi (Baird, 1863)

Only three of these species were found to be common in more than three samples: Glycymeris subobsoleta (54 samples), Tellina nucleoides (20 samples), and Homalopoma luridum (4 samples).

Glycymeris subobsoleta was the dominant species found in the carbonate-rich gravels of Laskeek Bank and eastern Dogfish Bank (Figure 20). In some samples, over ninety percent of the

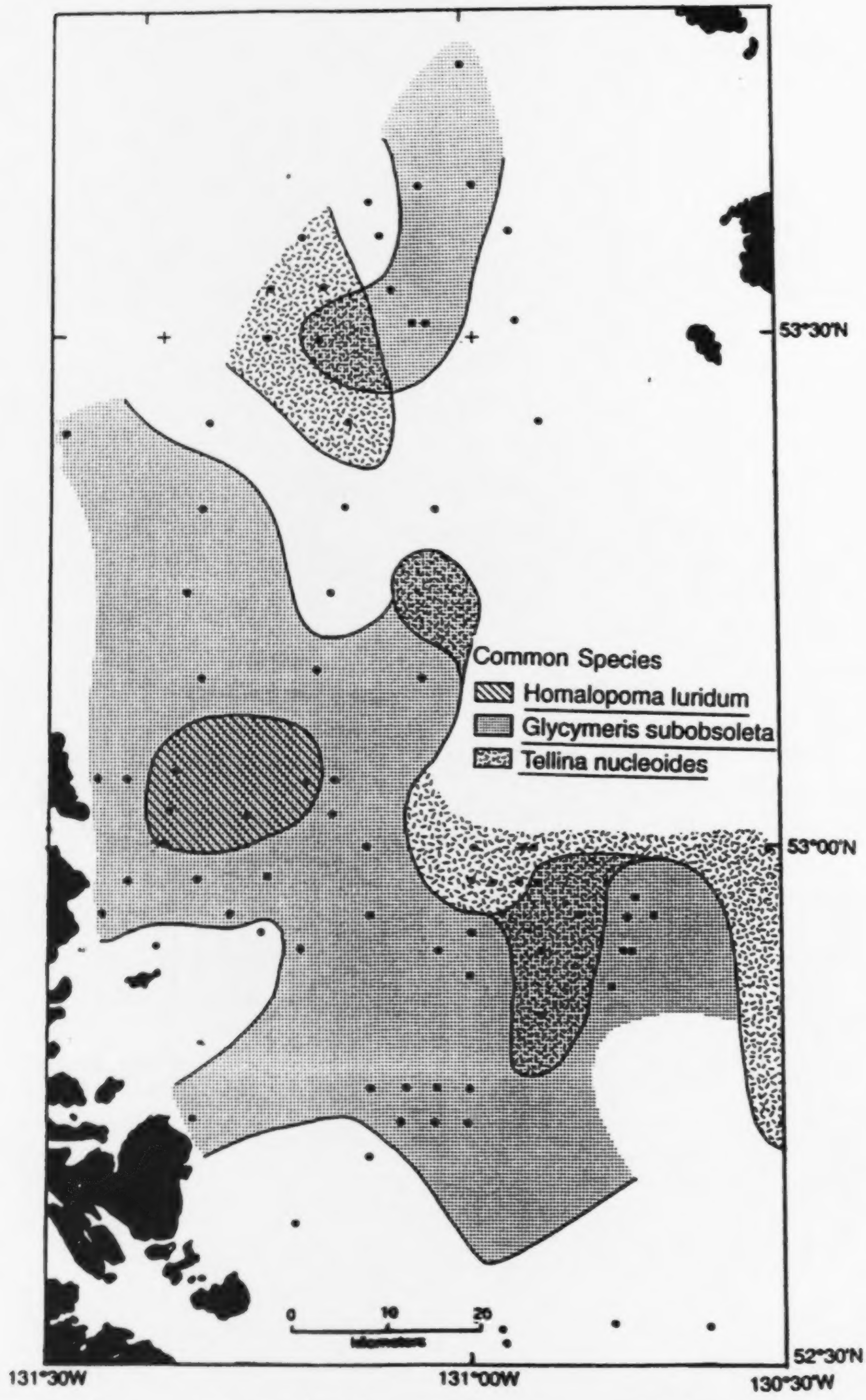

53°30'N
53°00'N
52°30'N
131°30W
131°00W
130°30'W
Common Species
Homalopoma luridum
Glycymeris subobsoleta
Tellina nucleoides
0
10
20
kilometers

Figure 20. Distribution of the species Glycymeris subobsoleta, Tellina nucleoides and Homalopoma luridum. Shaded areas show where these species have a relative abundance greater than 4 (common).

identifiable molluscs were identified as this bivalve. The gastropod *Homalopoma luridum* was also common in the most carbonate-rich, gravelly zone of eastern Laskeek Bank. In the sandy regions of Dogfish Bank and eastern Laskeek Bank, the bivalve *Tellina salmonea* is predominant in the sediment. Data is insufficient to determine the dominant molluscan species in deep water, owing to the low concentrations of molluscan material in deep water samples.

Substrate index is a value indicating the relative importance of gravel and rock-dwelling species in the sample. The distribution of these species (Figure 21) is similar to that of gravel (Figure 13). It also shows a strong correlation to the distribution of *Glycymeris subobsoleta*, although that bivalve can live in either sandy or gravelly habitats. In Hecate Strait, most of the accessory components associated with this bivalve prefer rock or gravel substrates. The substrate hardness indices show a fair correlation (r=0.61) with gravel content (Figure 22a), and a stronger correlation (r=.66) with the carbonate content of the sand fraction of the samples (Figure 22b).

The shallowness index is a measure of the importance of shallow-water fauna in the sediment. The correlation of shallowness index with water depth is difficult to recognize in map view, as there are few deep water samples (Figure 23). However, when water depth is plotted against shallowness index (Figure 24), there is a moderately strong negative correlation

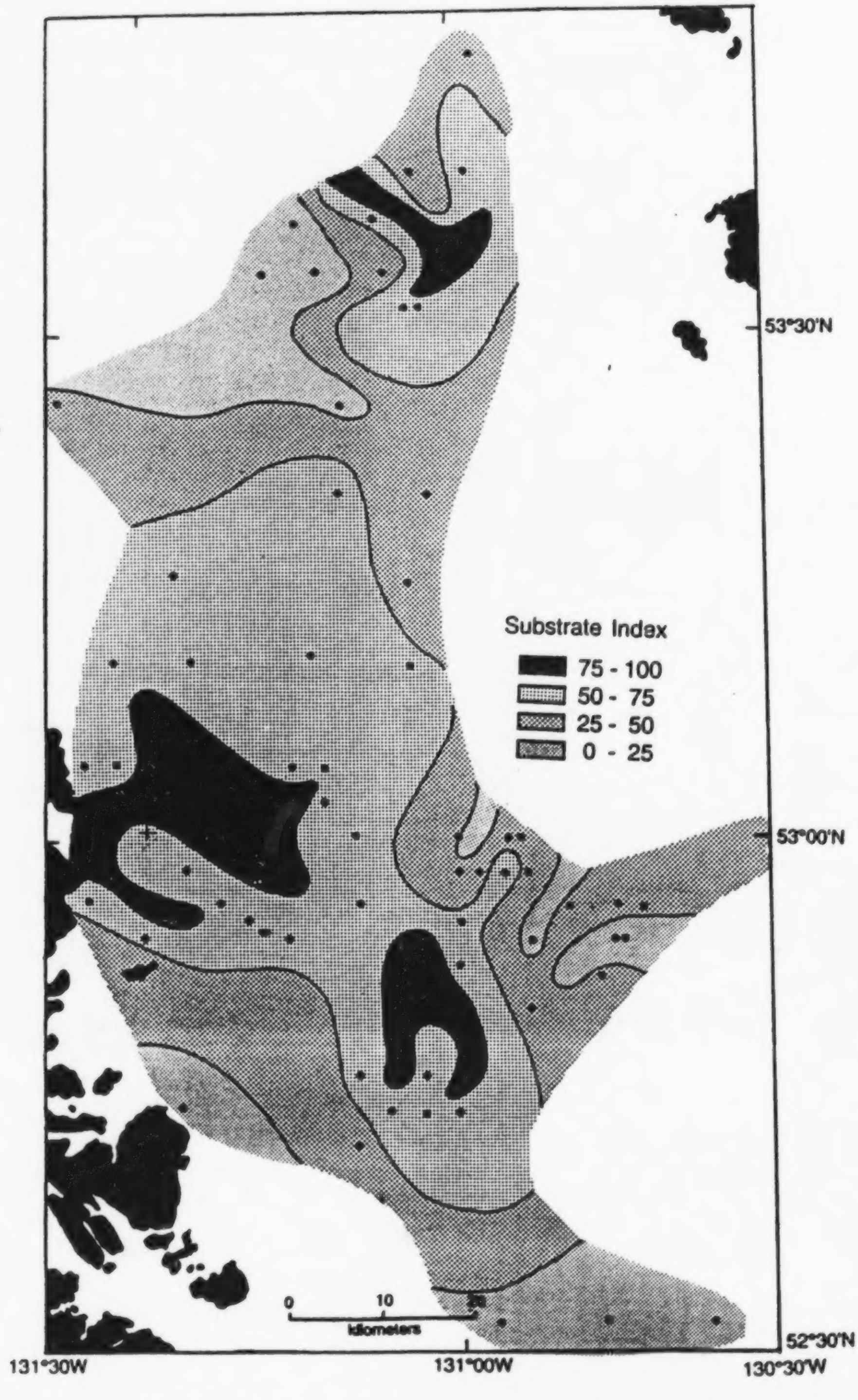

Substrate Index
75 - 100
50 - 75
25 - 50
0 - 25
53°30'N
53°00'N
52°30'N
131°30W
131°00W
130°30'W
0
10
20
kilometers

Figure 21. Distribution of the faunal Substrate Index in Hecate Strait. High values indicate a predominance of rock and gravel dwelling fauna. Compare Figure 13.

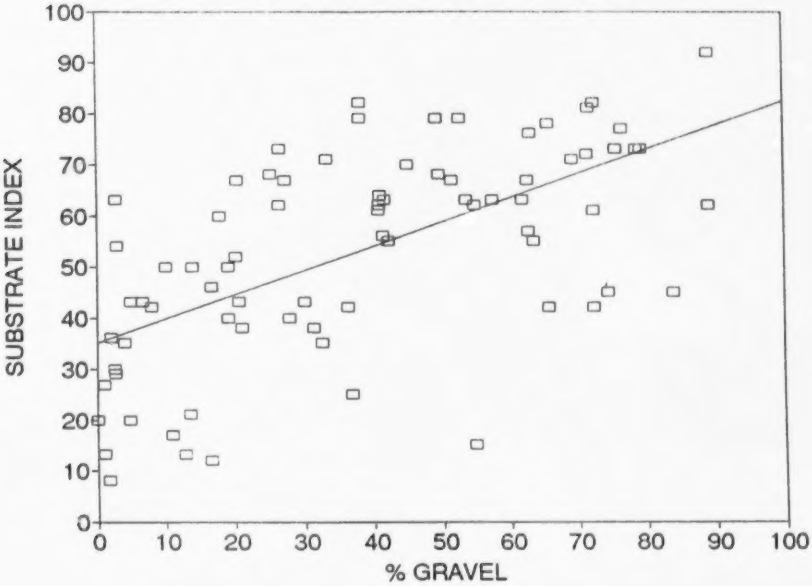


Figure 22a. Plot of gravel content vs. Substrate Index for 77 samples in Hecate Strait. The linear regression line has a correlation coefficient of r=0.61.

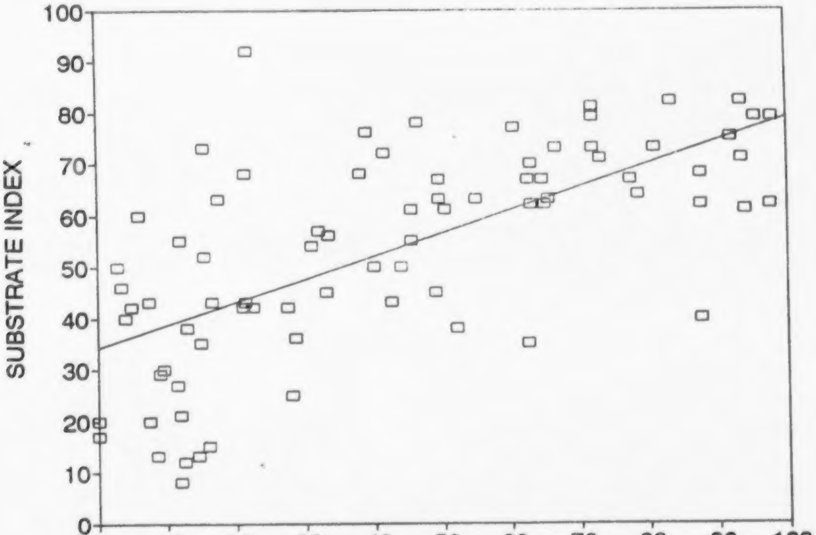


Figure 22b. Plot of carbonate content of the sand fraction vs. the substrate index for 79 samples from Hecate Strait. The linear regression coefficient for the line shown is 0.66.

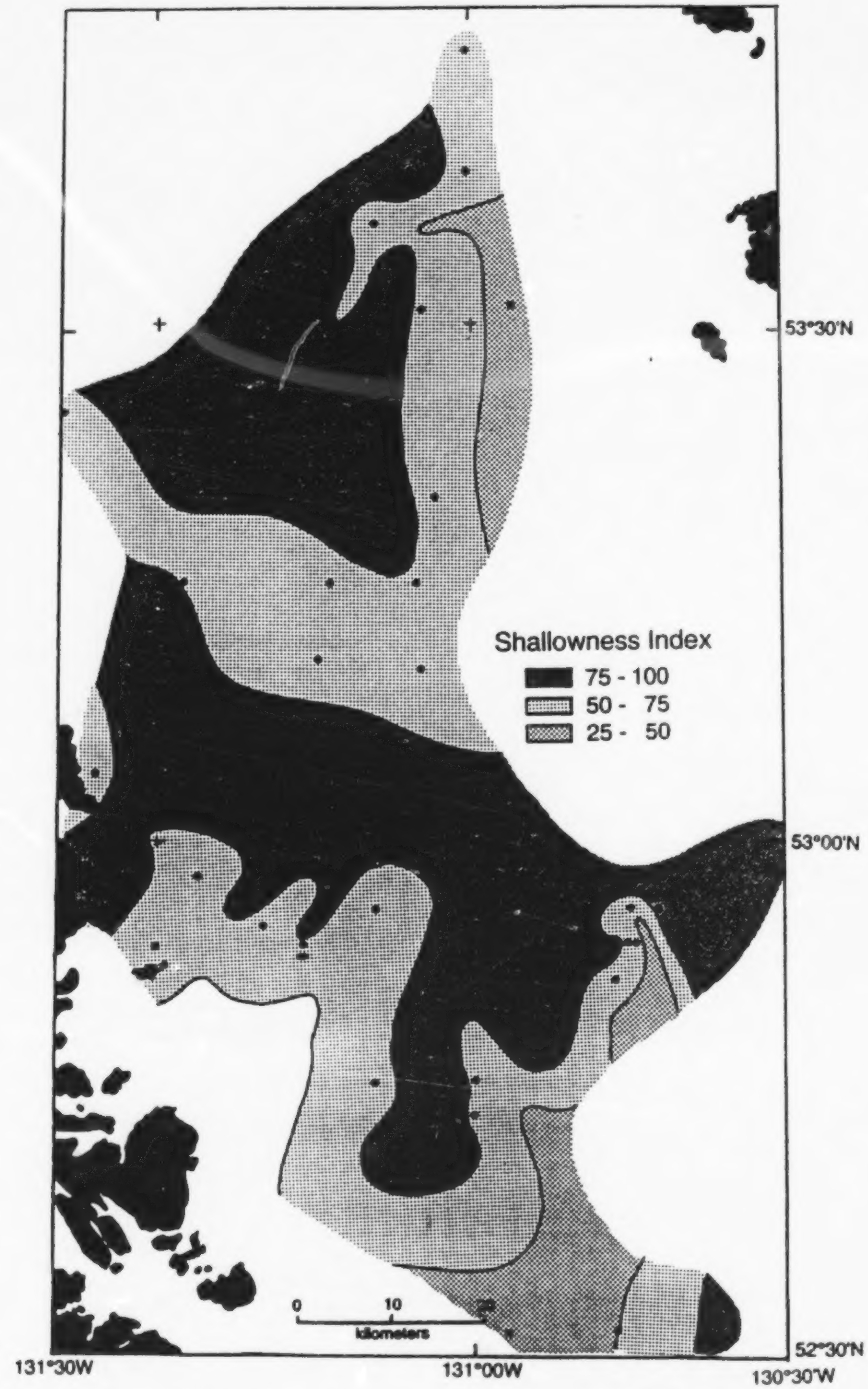

Shallowness Index
75 - 100
50 - 75
25 - 50
53°30'N
53°00'N
52°30'N
131°30W
131°00W
130°30'W
0
10
20
kilometers

Figure 23. Distribution of Shallowness Index in Hecate Strait. High values indicate a predominance of shallow-water (<50 m) fauna.

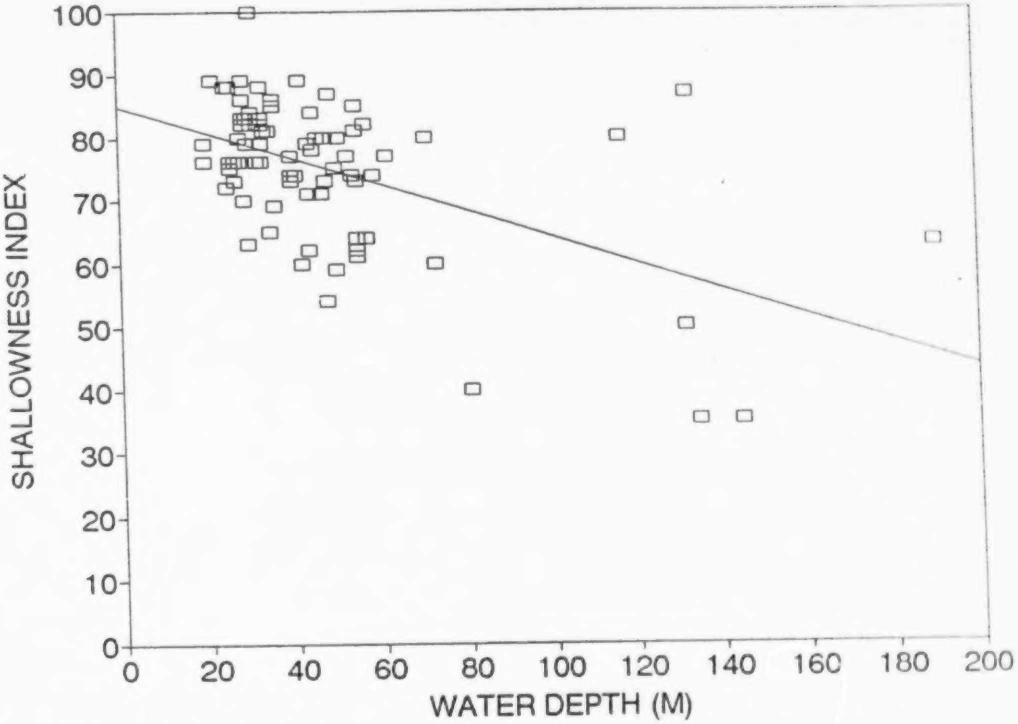


Figure 24. Correlation between Shallowness Index and water depth for 80 samples from Hecate Strait. The linear regression coefficient for the line shown is -0.53.

(r=-0.53), although there is considerable scatter, especially in very deep (>100m) water.

The cluster analysis produced six classes with no similarity between them, indicating that the least similar samples from each cluster do not contain any of the same species (Figure 25). The largest cluster, Class II, was further subdivided into IIa and IIb using a similarity criterion of 0.20.

Tellina nucleoides constitutes more than 5% of all Class I samples, and is typically the dominant species. Many of these samples are almost monospecific. Glycymeris subobsoleta is nearly always present, but rarely as abundant as T. nucleoides. Pododesmus cepio and Olivella baetica are also commonly present. Class I samples consistently have very high shallowness indices and low substrate hardness indices (Figure 26), indicating that this is a shallow water, sandy bottom assemblage.

Class II samples contain the greatest diversity of molluscan fauna. Although the differences between Class IIa and Class IIb are subtle, the two subclasses were found to have distinctly different spatial distributions. Glycymeris subobsoleta is the dominant species in all Class II samples. Homalopoma luridum, Miodontiscus prolongata, Pododesmus cepio, and Humilaria kennerlyi are usually present in both subdivisions of Class II. In Class IIa, Crepidula dorsata and for 80 samples from Hecate Strait. Class VI, containing only

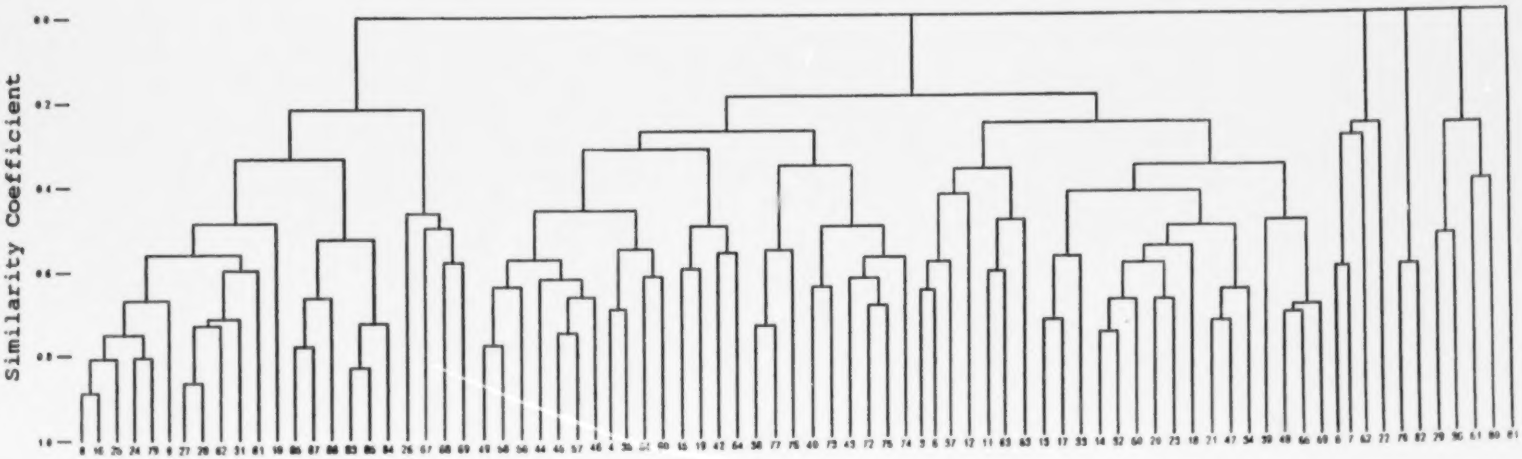


Figure 25. Complete-linkage cluster analysis of faunal data for 80 samples from Hecate Strait using the Kulczynski (1927) similarity coefficient.

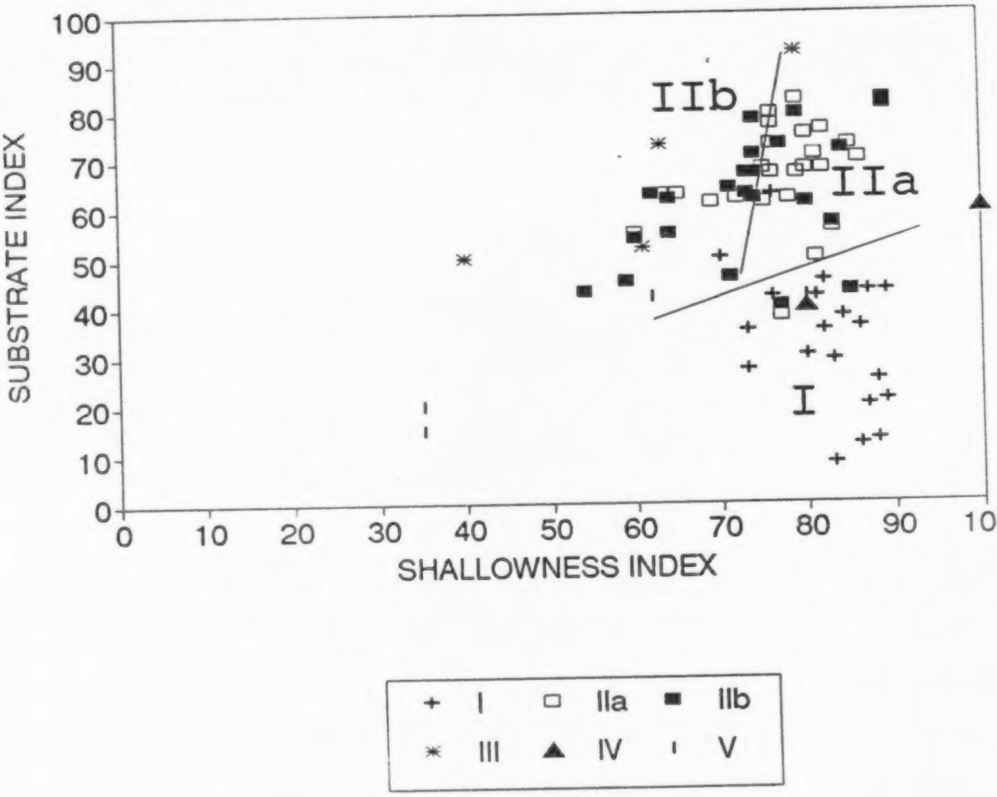


Figure 26. Substrate index plotted against shallowness index one sample is omitted. The general range of classes I, IIa and IIb is shown. This gives an indication of the habitat for these faunal classes.

Calyptraea fastigiata are very common, and *Tellina nucleoides* is usually present as a minor component. All of these species may be found in Class IIb samples, but are less important. Class IIb samples commonly contain *Chlamys rubida*, *Diplodonta orbella*, *Cyclocardia crassidens*, *Tridonta alaskensis*, *Puncturella multistriata*, and *Amphissa columbiana*. Again, these species also occur in Class IIa, but are volumetrically less important. Both subclasses have moderate to high shallowness indices and substrate hardness indices (Figure 26), indicating that these fauna would normally live in shallow to intermediate water depths, with hard or mixed substrates. Although there is considerable overlap, in general, samples in Class IIb contain somewhat more deep-water species.

All Class III samples contain *Lepeta caeca* and *Chlamys rubida*, with *L. caeca* generally more prominent. *Cyclocardia ventricosa*, *Crepidula dorsata* and *Crepidula nummaria* may also be important. This fauna suggests an origin in intermediate to deep water and rocky or gravelly substrates (Figure 26).

Only two samples, both very small, are classified as Class IV. As the samples were small, they may not be representative, but the absence of *Glycymeris subobsoleta* and *Tellina nucleoides* is striking. Both samples contained *Amphissa columbiana*. This faunal assemblage is suggestive of shallow water with a mixed sandy and rocky or gravelly bottom.

In Class V samples, *Cyclocardia ventricosa* is always present, and usually the most abundant species. Chlamys rubida and Psephidia lordi are commonly present. These samples are widely spread in Figure 26, ranging from deep water, soft substrate assemblages to shallower assemblages of intermediate substrate.

Class VI is a single, small sample with a very unusual composition: Clinocardium californiense, Macoma carlottensis, and Margarites pupillus. C. californiense and M. carlottensis are deep-water, sandy substrate species, but M. pupillus is a shallow water species.

The spatial distributions of the faunal classes are shown in Figure 27, and with respect to gravel content and water depth in Figure 28. Class I samples are found in the sandy, carbonate-poor regions of Dogfish Bank and western Laskeek Bank. These samples are mostly restricted to water depths of less than 60m in sand or gravelly sand substrates. Two of these samples were predominantly gravel, although they came from less gravelly regions of the map. Two samples were from water depths greater than 100m in southern Hecate Strait.

Class II samples are typical of all the shallow, carbonate-rich areas. Class IIa samples are found over most of the northern parts of Laskeek Bank, while Class IIb samples are concentrated along the basinward margins of Laskeek bank, and in the carbonate rich zone of western Dogfish Bank. These samples generally had gravel contents greater than 25%, except those in water deeper than 50m. In water depths of less than

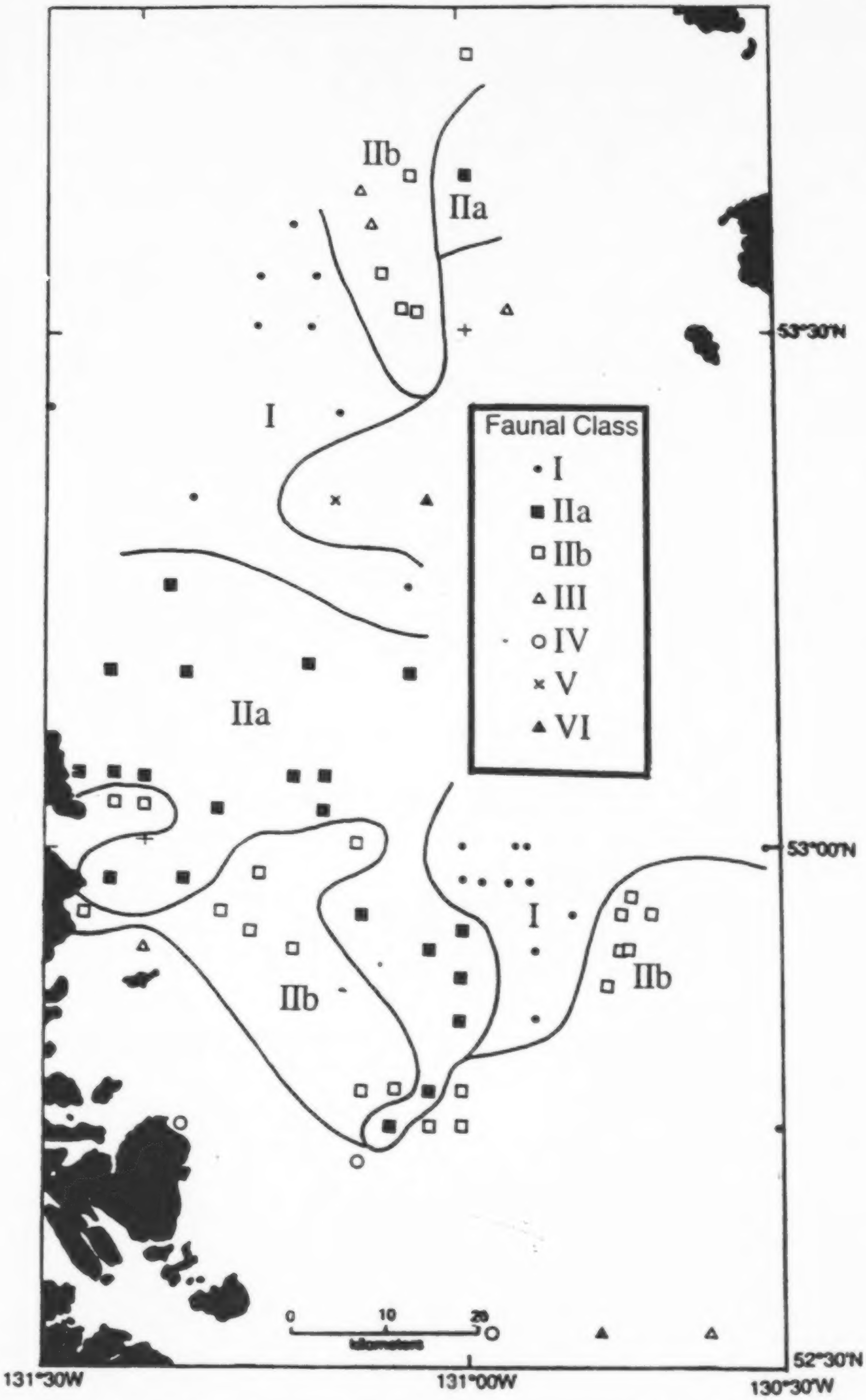

IIb
IIa
I
IIa
IIb
I
IIb
Faunal Class
• I
■ IIa
□ IIb
△ III
○ IV
× V
▲ VI
53°30'N
53°00'N
52°30'N
131°30W
131°00W
130°30'W
0
10
20
kilometers

Figure 27. Distribution of faunal classes in Hecate Strait. Classes defined by the results of the cluster analysis shown in Figure 25.

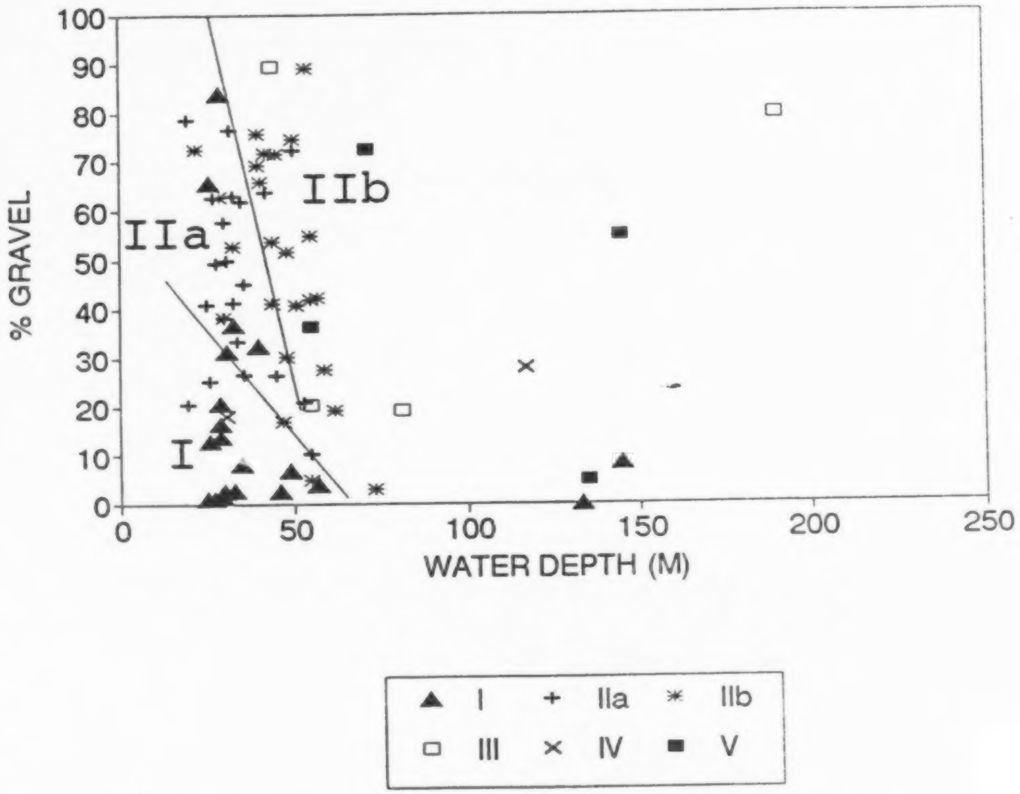


Figure 28. Plot of water depth vs. gravel content for 80 faunal samples in Hecate Strait, indicating the settings in which these faunal assemblages were found. The general ranges of Classes I and II are shown.

40m, Class IIa predominated, while deeper water samples were mostly Class IIb.

Three of the Class III samples are located in deeper water around the margins of the high carbonate zone, and the fourth on Laskeek Bank. These are from an extremely wide range of water depths and grain sizes.

One of the Class IV samples is from Dogfish Bank, and the other from much deeper water (115m) in southern Hecate Strait. Both are from gravelly sands.

All of the Class V samples are from deeper water (>50m) in both the southern and northern parts of the study area. Gravel contents varied widely.

The lone Class VI sample is from a sand sample from a depth of 120m in southern Hecate Strait.

In summary, the faunal assemblages vary with water depth, and especially with substrate in a fairly consistent fashion. The bivalve Glycymeris subobsoleta and a diverse assemblage of other mollusks, most of which prefer rocky or gravelly substrates, dominate in the carbonate-rich, gravelly sediments of Laskeek Bank and eastern Dogfish Bank. There is a subtle faunal change from shallower to deeper water in these areas, indicated by a shift from Class IIa to Class IIb. In less carbonate-rich, predominantly sandy sediments of Dogfish Bank and eastern Laskeek Bank, Tellina nucleoides, a shallow water, sandy bottom species is the most common species. No single dominant species was found in the deep water sediments and there was considerable variation between samples, though this may be due in part to small sample sizes.

5. Scanning Electron Micrograph Results

The *Tellina* shells from a water depth of 29m in sand, and the two *Glycymeris* samples from water depths of 27m in gravel showed remarkably similar features under SEM. The majority of the shells are extremely intensely bored by microorganisms (Figs. 29a and 29b). These are similar to those from Cook Bank described by Young and Nelson (1988). The margins of many of the borings are uneven or angular (Figure 29c), and shell surfaces show features similar to those resulting from inorganic dissolution or maceration (Alexandersson, 1975;1979, Young and Bornhold (1988). Bioerosion appears to be the dominant process in the shallower water samples, although usually only the surficial layers of the shell are intensely bored. However, heavily bored material is more readily removed by abrasion, so outer shell layers may rapidly be lost following intense bioerosion.

The two samples from deeper water also displayed etching patterns, but were less extensively bored. The shell surfaces appeared abraded and pitted (Figure 29d).

6. Radiocarbon Dates

Of the five dates obtained from surficial shell samples from Laskeek Bank, none was older than 1455 BP (Table III),

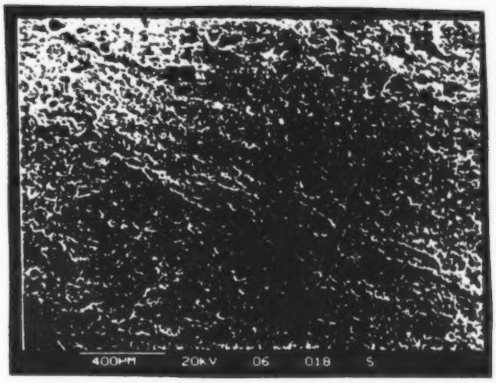

400µm 20KV 06 018 S

Figure 29a. Intensely bored Tellina nucleoides valve from a water depth of 27m on Dogfish Bank.

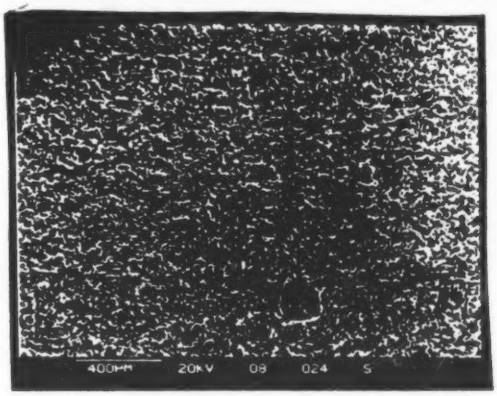

400µm 20KV 08 024 S

Figure 29b. Intensely bored Glycymeris subobsoleta valve from a water depth of 29m on Laskeek Bank.

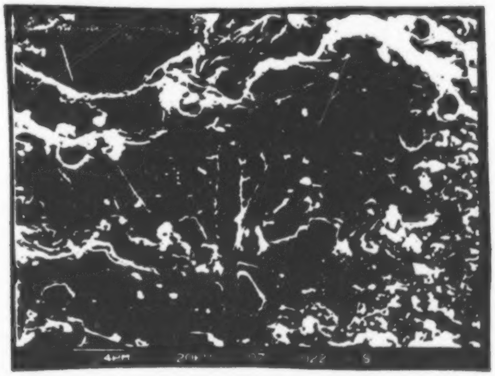


Figure 29c. Close-up of borings in G. subobsoleta valve. Note uneven walls of borings with shell layers appearing to "peel" along crystal faces.

the oldest date obtained from a mixed shell hash at a water depth of 45 m. Two samples of fresh-appearing samples were dated, one a Humilaria kennerlyi shell, the other a collection of Glycymeris subobsoleta shells and fragments. One of these (GX-8164) had a higher activity rate than the 1950 standard, indicating a more recent origin, and the other gave an apparent age of 25 +/- 125 BP (GX-8166).

Table IV. Radiocarbon Dates from Hecate Strait

Sample	Depth	Location/Description	C-14 years BP
GX-8164	22m	53 02.1'N 131 30.1'W Humilaria kennerlyi shell	Modern
GX-8165	54m	52 54.0'N 131 16.1'W Glycymeris (worn shells)	870 +/- 140
GX-8166	54m	52 54.0'N 131 16.1'W Glycymeris (fresh shells)	Modern
GX-8167	32m	52 56.0'N 131 06.2'W shell fragment	715 +/- 115
GX-8168	45m	52 46.0'N 131 03.1'W mixed shell hash	1455 +/- 130
Beta-45007	29m	53 33.0'N 131 13.3'W Tellina nucleoides shells	2230 +/- 50*

* not C-13 corrected

The bulk sample of Tellina nucleoides shells from Dogfish Bank, gave a date of 2230 +/- 50 BP (Beta-45007).

7. Geophysical Data

The stratigraphy of the quaternary sediments of Hecate Strait has been described by Barrie (1988) and Barrie and Bornhold (1989). However, geophysical coverage in the shallow (<50m) areas of the strait, where the carbonate sediments are located, is fairly poor (Figure 8).

Huntec DTS lines throughout the area show the sediments as seismically hard nearly everywhere in the strait above a water depth of about 75m, and is mostly classified as bedrock by Barrie and Bornhold (1989). The bank top is fairly flat, with local relief generally less than 5 m, and sediment penetration by the Huntec DTS is restricted to a maximum of 2 metres (Figure 30) . This may partially reflect the gravelly nature of the sediments, but as the surficial sediment thickness cannot be resolved on the air gun lines, it cannot exceed 3m. The principal exception to this is in Pleistocene fluvial channels, most of which are completely filled with stratified sands (Barrie and Bornhold, 1989). A large channel, cut obliquely by the seismic line, is shown in Figure 31. These channels, generally oriented N-S to NW-SE are a common feature of northern Dogfish Bank (Barrie and Bornhold, 1989), and of the area of Dogfish Bank to the west and south of the carbonate rich zone. No fluvial channels were seen on any lines from Laskeek Bank in water depths of less than 75m, but seismic coverage is limited.

Sidescan sonar records show that bedrock outcrop is extensive, particularly on Laskeek Bank (Figure 32). Bedrock typically outcrops in low ridges with shallow, gravelly or sandy sediments concentrated in lows and flat areas of the bank. These sediments often compose large, straight to sinuous crested symmetrical bedforms with crests oriented NE

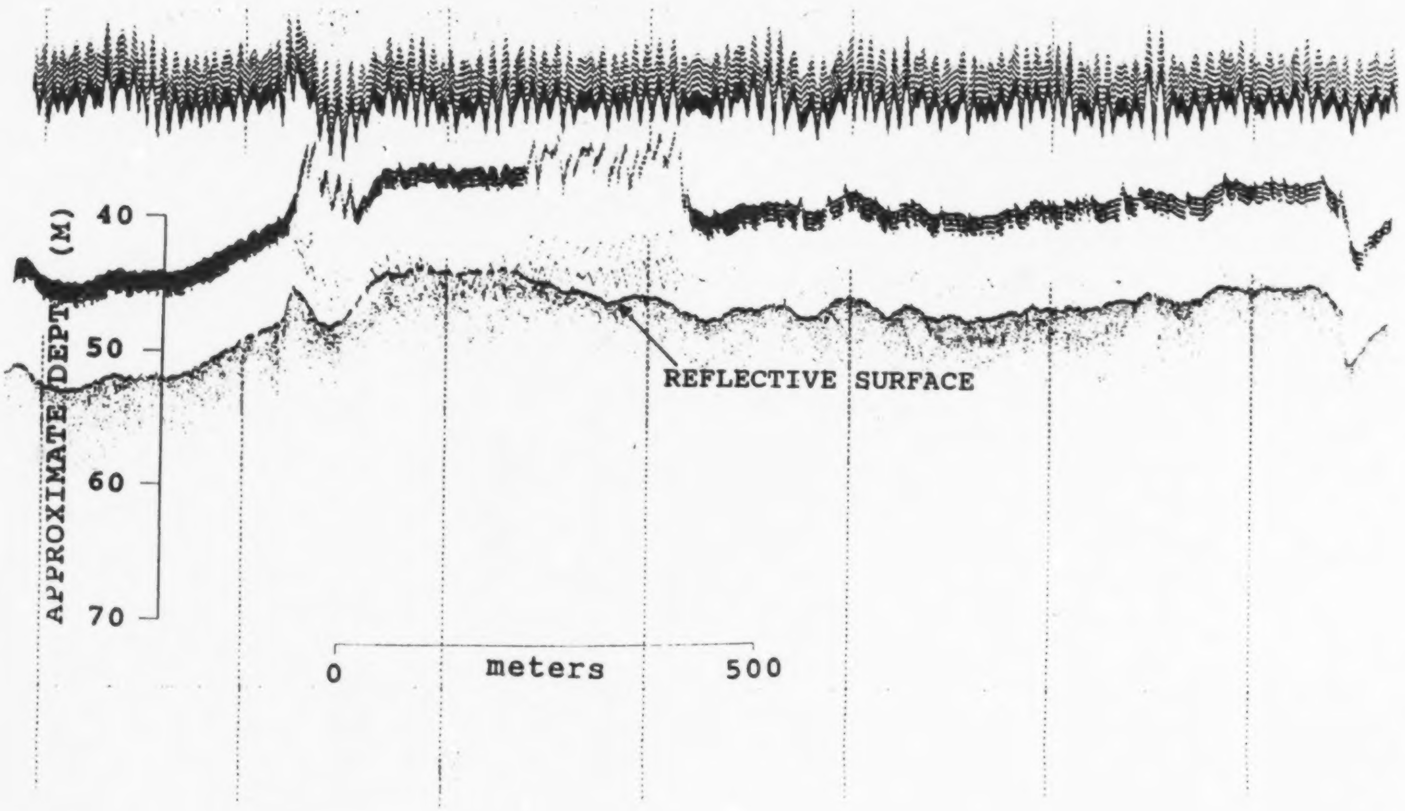


Figure 30. A typical Huntec Deep Tow Seismic line from Laskeek Bank, location 1 on Figure 8. Note acoustically reflective surface, indicating bedrock or coarse gravel.

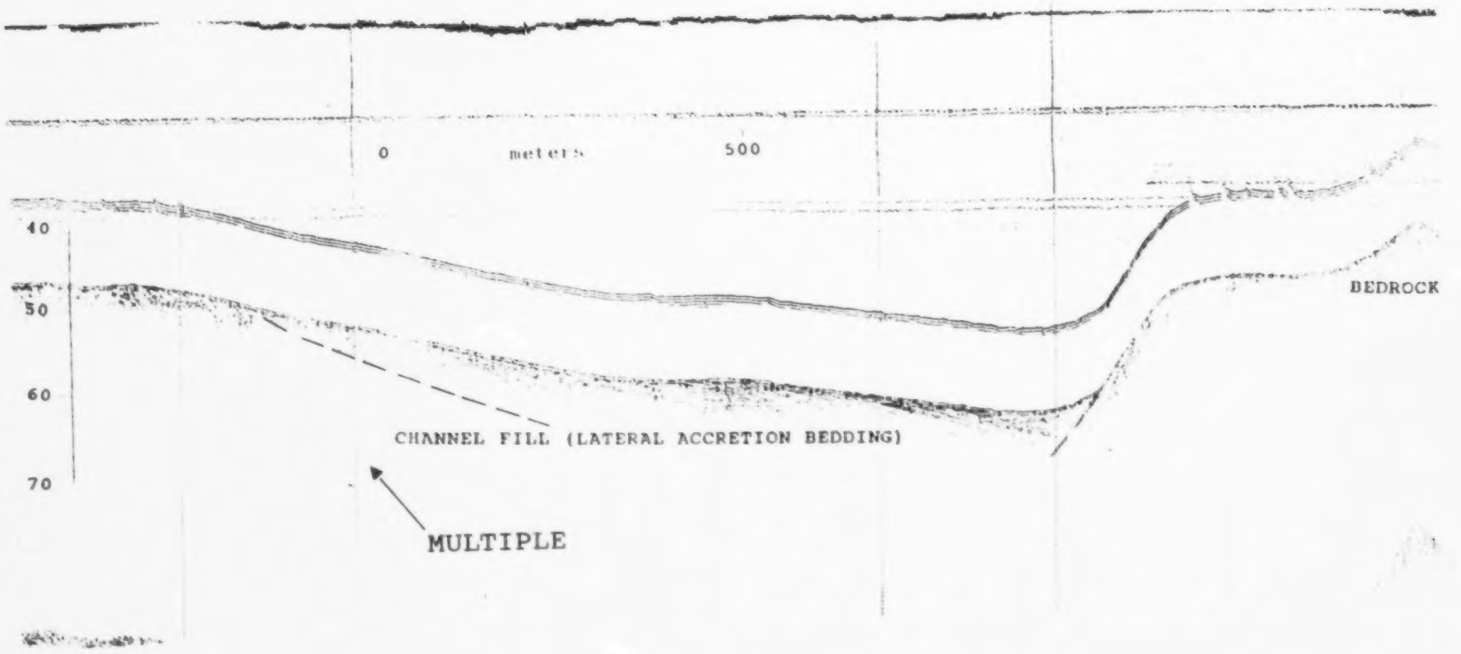


Figure 31. Huntec Deep Tow Seismic record from location 2 (Figure 8) The line obliquely cuts a large channel on Dogfish Bank, displaying lateral accretion bedding.

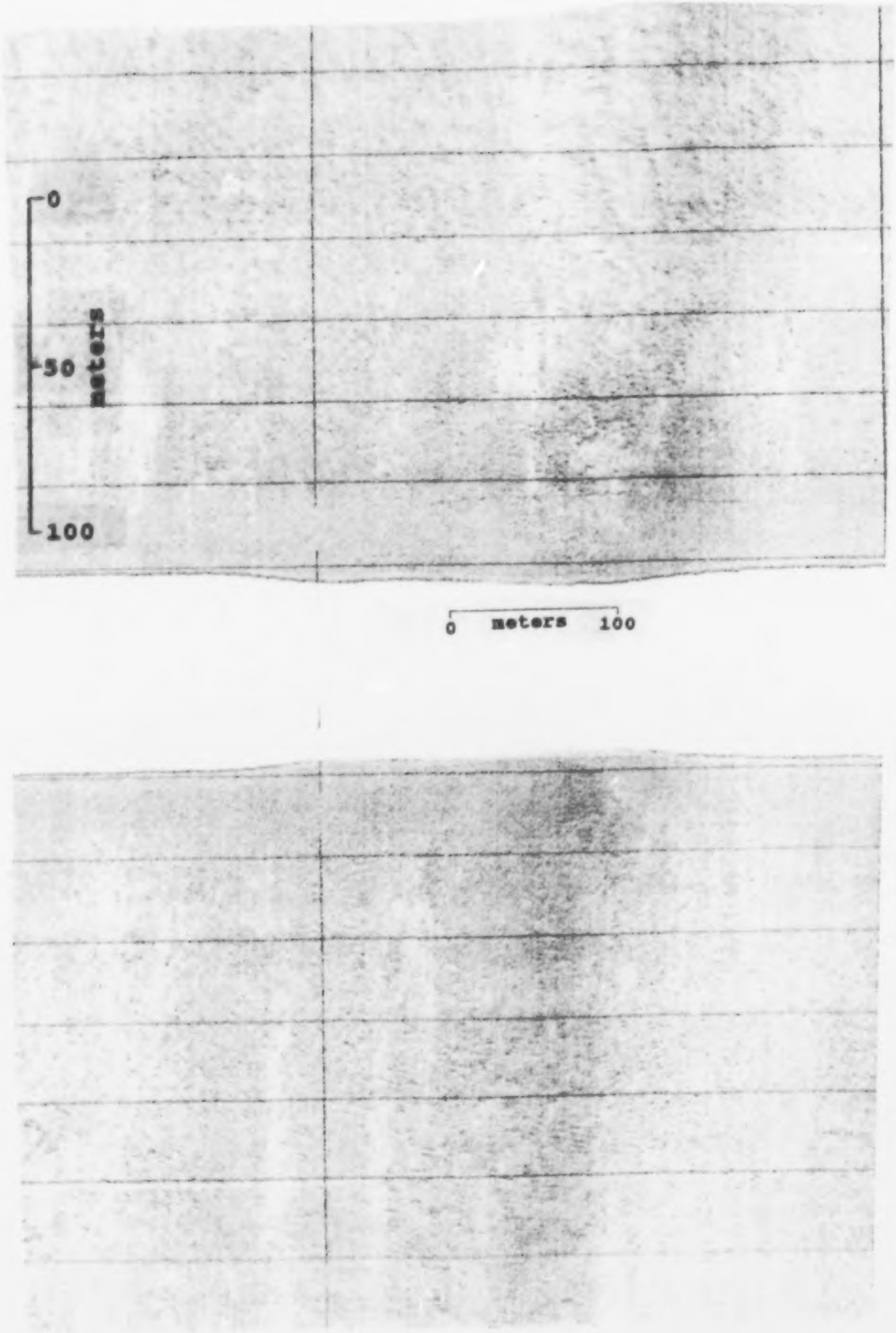

0
50
100
meters
0 meters 100

Figure 32. Side-scan sonar record of extensive bedrock outcrop on Laskeek Bank, Location 3 (Figure 8). Water depth is approximately 60m.

to SW and wavelengths of 2 to 3m (Figure 33). These features were described as large oscillation ripples by Barrie and Bornhold (1989). The rippled sediments are found in linear bands up to 50m wide, oriented perpendicular or nearly perpendicular to the wave ripple crests. These were the only bedforms seen in the shallow parts of Laskeek Bank, although sand ridges are present in slightly deeper water (50-60m) and in shallow water (15-20m) on Dogfish Bank (Moslow et al., 1989). In water depths of 50-100m the full suite of bedforms described by Luternauer and Murray (1983) from Queen Charlotte Sound, may be seen in Hecate Strait. Using the terminology of Ashley et al. (1990), the large barchanoid sand waves and smaller asymmetric sand waves would be classified as large 3-D dunes and small to medium-sized 2-D dunes (Figure 34).

Bedrock outcrops at the surface throughout much of the surveyed part of Laskeek Bank, and appears to be randomly distributed. No clear relationship between bedrock outcrop and either gravel content or carbonate content of the sediment could be recognized at a local scale.

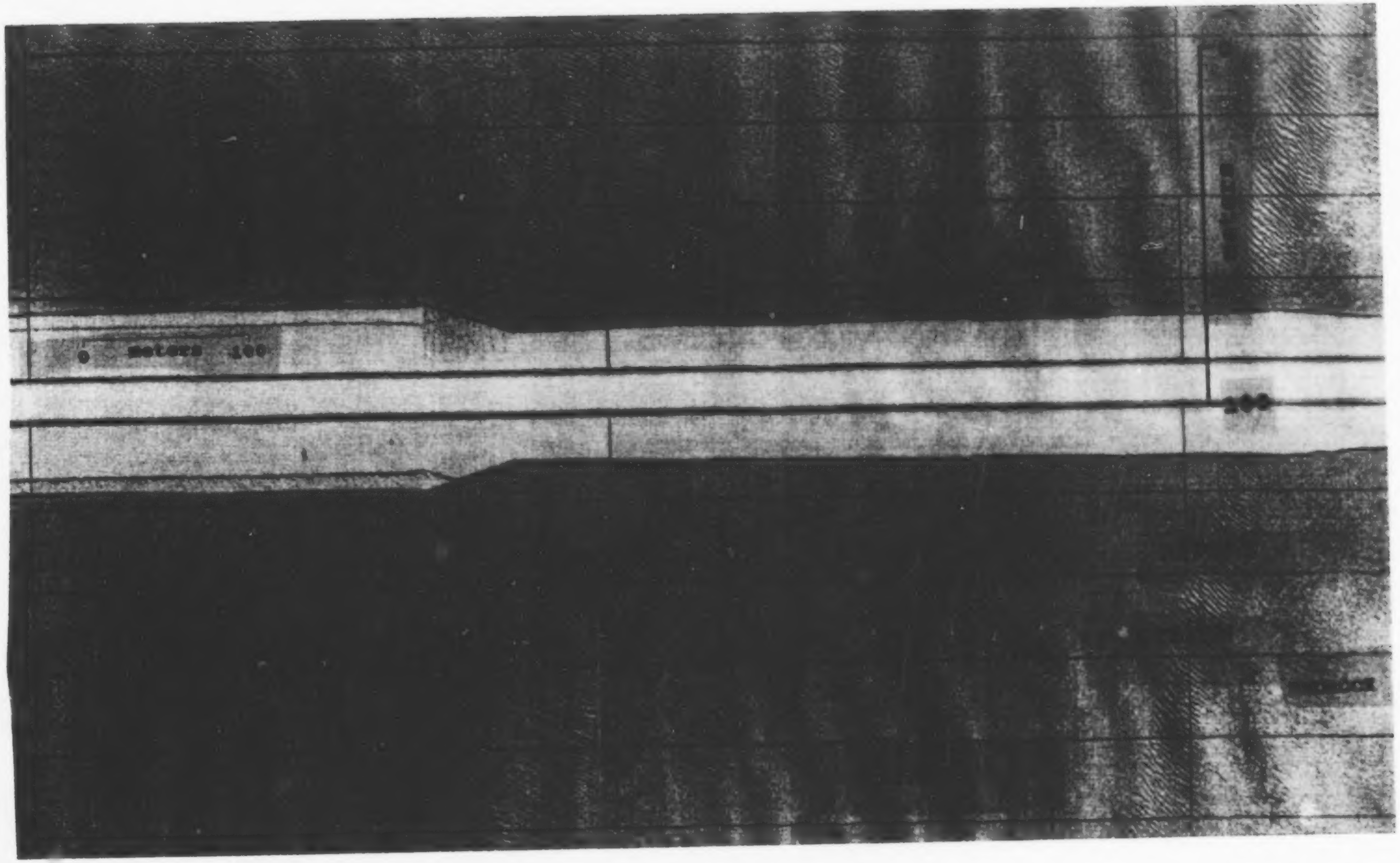

0 meters 100
200

Figure 33. Ribbons of large oscillatory ripples on Laskeek Bank, Location 4 (Figure 8). Water depth is approximately 40m.

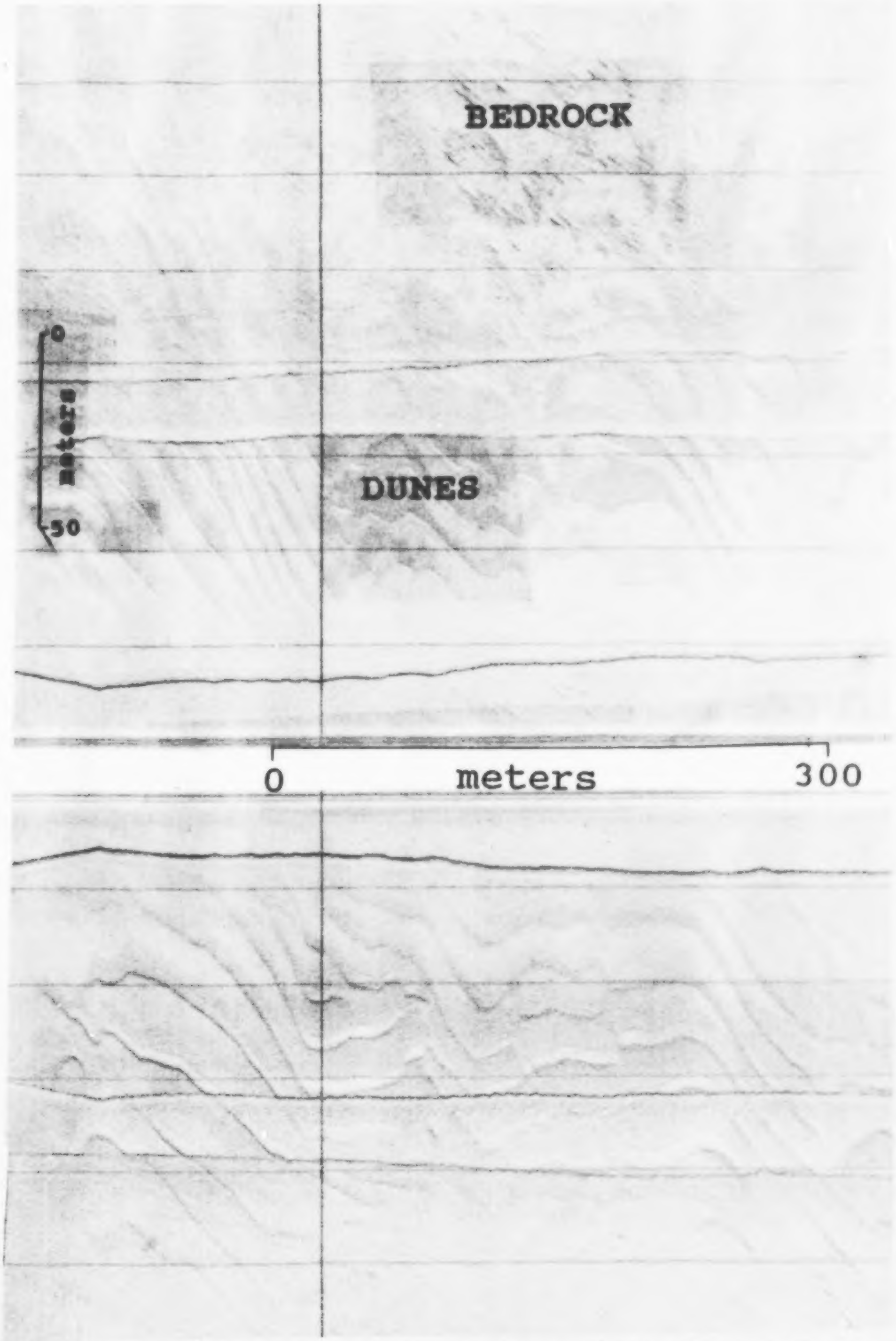


Figure 34. Sinuous-crested 2-D dunes in basin southwest of Laskeek Bank, Location 5 (Figure 8). Water depth is approximately 100m.

B. Cook Bank

1. Carbonate Content

Carbonate-rich sediments are restricted to the areas in the vicinity of the Scott Islands and the shelf immediately to the north (Figure 35). Carbonate content declines steeply to the south and north, and more gradually to the west and east. Water depth does not seem to influence carbonate distribution as strongly as in Hecate Strait: carbonate contents exceed 25% in samples from water depths as great as 200m. However, very high (>75%) concentrations of carbonate are restricted to water depths less than 100m. The northern part of Cook Bank and the shelf extending northward from Vancouver Island are conspicuously poor (<25%) in carbonate. Due to additional data, this distribution differs in detail from the map of carbonate content by Nelson and Bornhold (1983), but shows essentially the same pattern.

2. Grain Size

Complete grain size data for Cook Bank are found in Appendix A. As in Hecate Strait, sands and gravels predominate, and appreciable mud contents are restricted to the deeper water areas (Figure 36). Gravel is concentrated in the shallow water adjacent to Vancouver Island, in an east-west band through the Scott Islands, and a north-south band extending north from Sartine Island. The high carbonate zone is located in the gravelly areas in the vicinity of the Scott

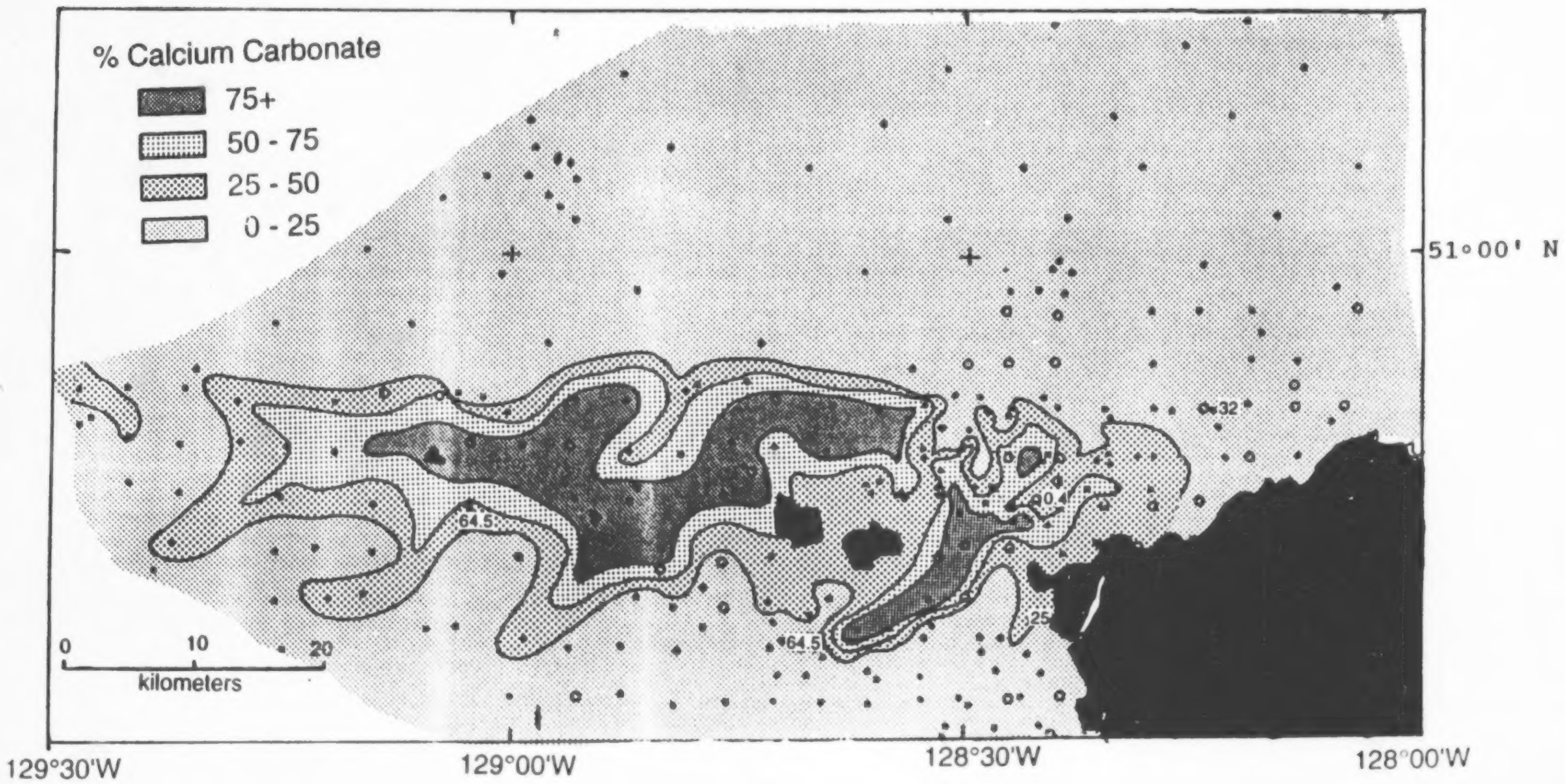

% Calcium Carbonate
75+
50 - 75
25 - 50
0 - 25
0
10
20
kilometers
64.5
64.5
20.4
25
32
51°00' N
129°30'W
129°00'W
128°30'W
128°00'W

Figure 35. Carbonate percentage by weight in the sand fraction, Cook Bank. Values shown are those which do not fit the generalized contours. Open circles denote samples where the carbonate percentage was based on visual estimate, rather than laboratory analysis.

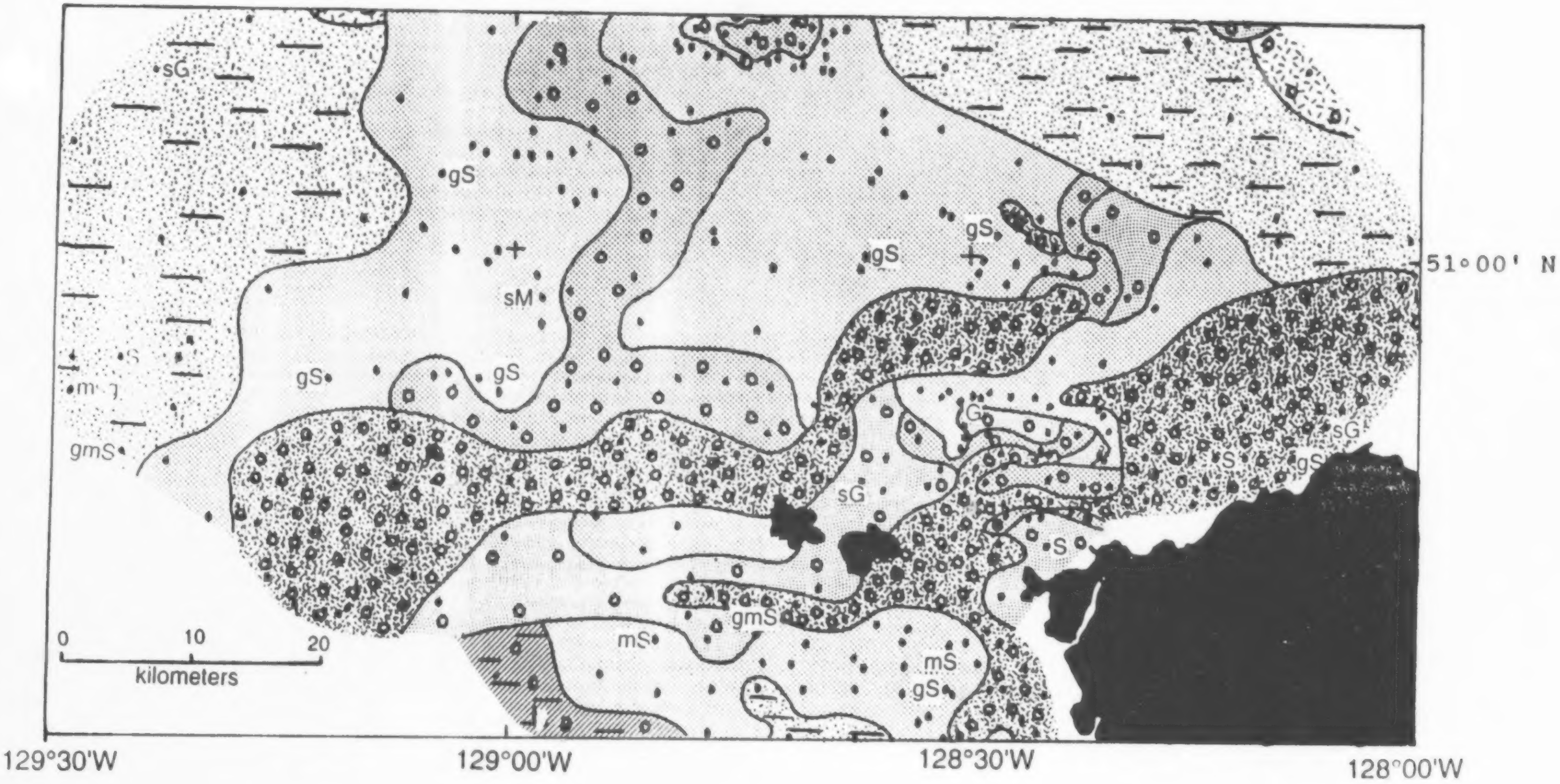

sG
gS
sM
gS
gS
gmS
S
m
gS
gS
G
sG
S
gS
sG
S
gmS
mS
mS
gS
0
10
20
kilometers
129°30'W
129°00'W
128°30'W
128°00'W
51°00' N

Figure 36. Sediment textures on Cook Bank using a modified Folk classification. Classification definitions shown in Figure 10. Annotated samples are anomalous.

Islands. However, there are many areas of gravelly sediments adjacent to Vancouver Island and on the northern half of Cook Bank which are carbonate-poor, even in relatively shallow (<100 m) water. This is in marked contrast to Hecate Strait, where there is an almost one-to-one correspondence between shallow, gravelly regions and abundant carbonate.

Although samples from shallow water adjacent to Vancouver Island often contained more than 90% gravel, mean grain size in this region is typically granule size (-1 to-2 phi); the grain size in the vicinity of the Scott Islands is pebble size (> -2 phi) (Nelson and Bornhold, 1983). As the grain size of the carbonate fraction from the Vancouver Island shelf is also lower than in the Scott Islands, it is clear that this is not wholly a reflection of the higher concentrations of carbonate in the sediment. The sediments around Vancouver Island are also somewhat better sorted, with a standard deviation of grain size ranging from 1 to 2 phi, as compared to greater than 2.5 phi in the high carbonate zone around the Scott Islands.

Due to the low carbonate contents of the shallow, gravelly areas adjacent to Vancouver Island, dividing the seafloor into 10' x 10' blocks did not improve the correlation of water depth and gravel content with carbonate content.

3. Faunal Data

The bivalve and gastropod faunas described by Nelson and

Bornhold (1983) are strikingly similar to those of Hecate Strait. Of the twenty-four most common bivalves and gastropods reported from Cook Bank, all but two (*Hinnites multirugosus* and *Caecum crebricinctum*) are also found in Hecate Strait samples.

Glycymeris subobsoleta is the most common species; indeed in most samples it is the only common species (Figure 37). No other species is common in more than three samples. The absence of a well-developed *Tellina nucleoides* zone is in contrast to Hecate Strait. However, in Hecate Strait, *T. nucleoides* is found predominantly in sandy sediments in shallow water; sandy substrates are uncommon in the shallow parts of Cook Bank.

As in Hecate Strait, carbonate-rich sediments were found primarily in *Glycymeris subobsoleta*-rich gravels. The other common species in the *Glycymeris subobsoleta* zone are *Chlamys rubida*, *Miodontiscus prolongata* and *Humilaria kennerlyi*, which were also common in Class II samples from Hecate Strait. Thus, the bioclastic sands and gravels contain a nearly identical molluscan fauna in the two areas. Samples similar to Class I (the *Tellina*-dominated group) were found in sands northeast of Triangle Island.

Few samples were from sands or low-carbonate areas. Those samples generally had no dominant species, but a fairly diverse assemblage. These samples did not have an obvious analog in Hecate Strait, and were too few in number to be

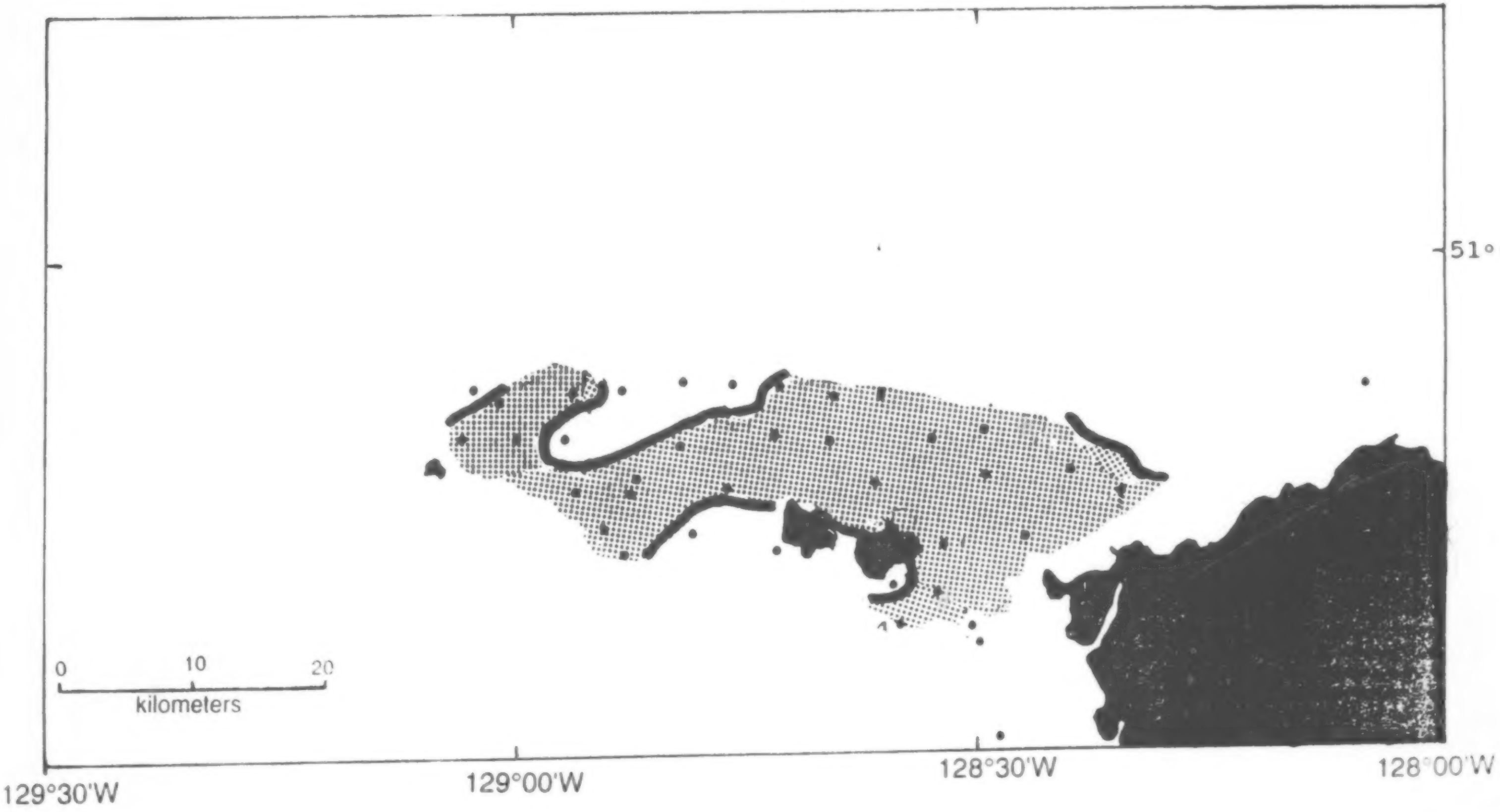

51°00' N
0
10
20
kilometers
129°30'W
129°00'W
128°30'W
128°00'W

Figure 37. Distribution of *Glycymeris subobsoleta* on Cook Bank. Relative abundance exceeds 4 (common) within the shaded region.

amenable to the cluster analysis techniques. As there were few samples from outside the Glycymeris zone, substrate hardness and shallowness indices were not calculated.

4. Geophysical Data

Luternauer and Murray (1983) and Luternauer et al. (1986) described the Late Quaternary stratigraphy and bedform distribution in Queen Charlotte Sound in some detail. A brief description of the principal features seen on geophysical records is presented here for purposes of comparison to Hecate Strait.

A striking feature of the Cook Bank area is the extremely rugged terrain of the Scott Islands region, especially in inter-island channels (Figure 38). In these areas the topographic highs are made up of exposed bedrock or have a thin sediment cover over them, while lows have thicker (up to 25m) packages of stratified sediments. In areas of gentler relief, such as northern Cook Bank, the sedimentary package gradually pinches out at a water depth of approximately 75m (Figure 39). As in Hecate Strait, there is little or no sediment cover in the shallow water areas, and exposed bedrock is common.

Sedimentary bedforms are similar to those found in Hecate Strait. Large oscillatory ripples are common in water depths of 40 to 90 m. In water depths of 60 to 110m, 2-D dunes with wavelengths of 10-15 m (Figure 40) are common. Where tidal

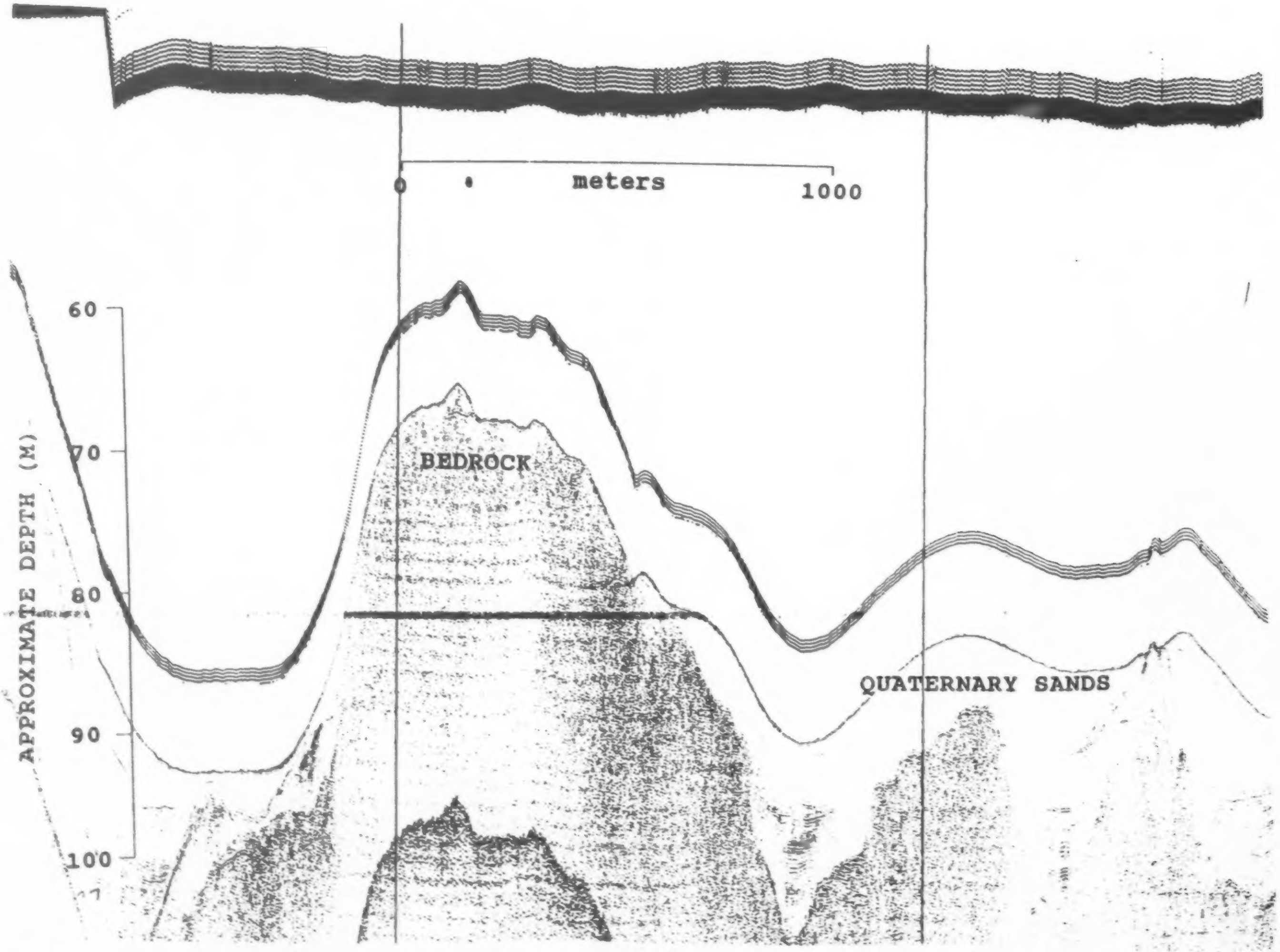


Figure 38. Rugged topography north of Cook Channel, Location 1 (Figure 9). Note contrast between thick sediment packages in lows and exposed bedrock highs.

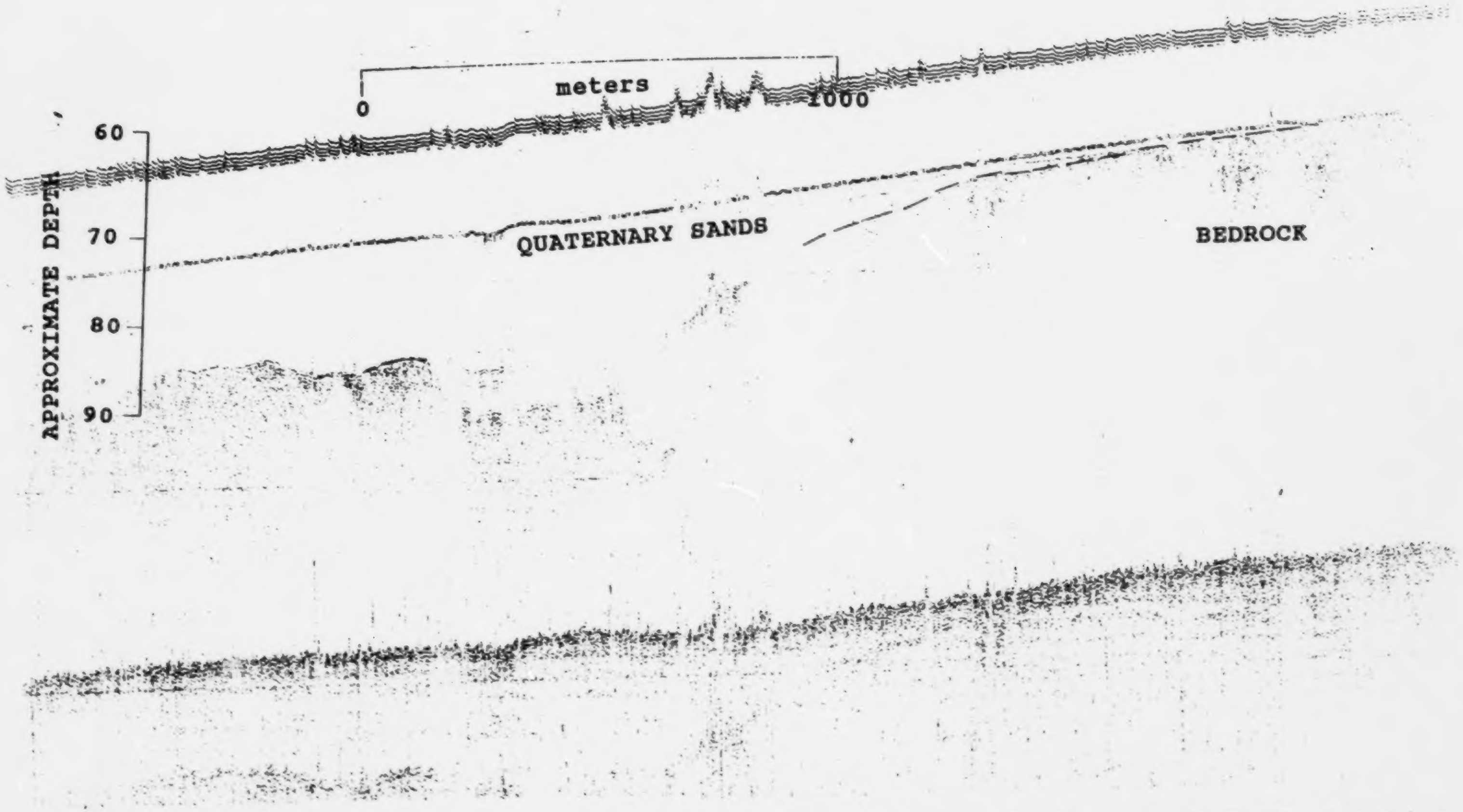


Figure 39. Gradual pinch-out of sediment at a water depth of 75m on Cook Bank, Location 2 (Figure 9). Huntec Deep-Tow Seismic record. Dashed line shows inferred bedrock surface.

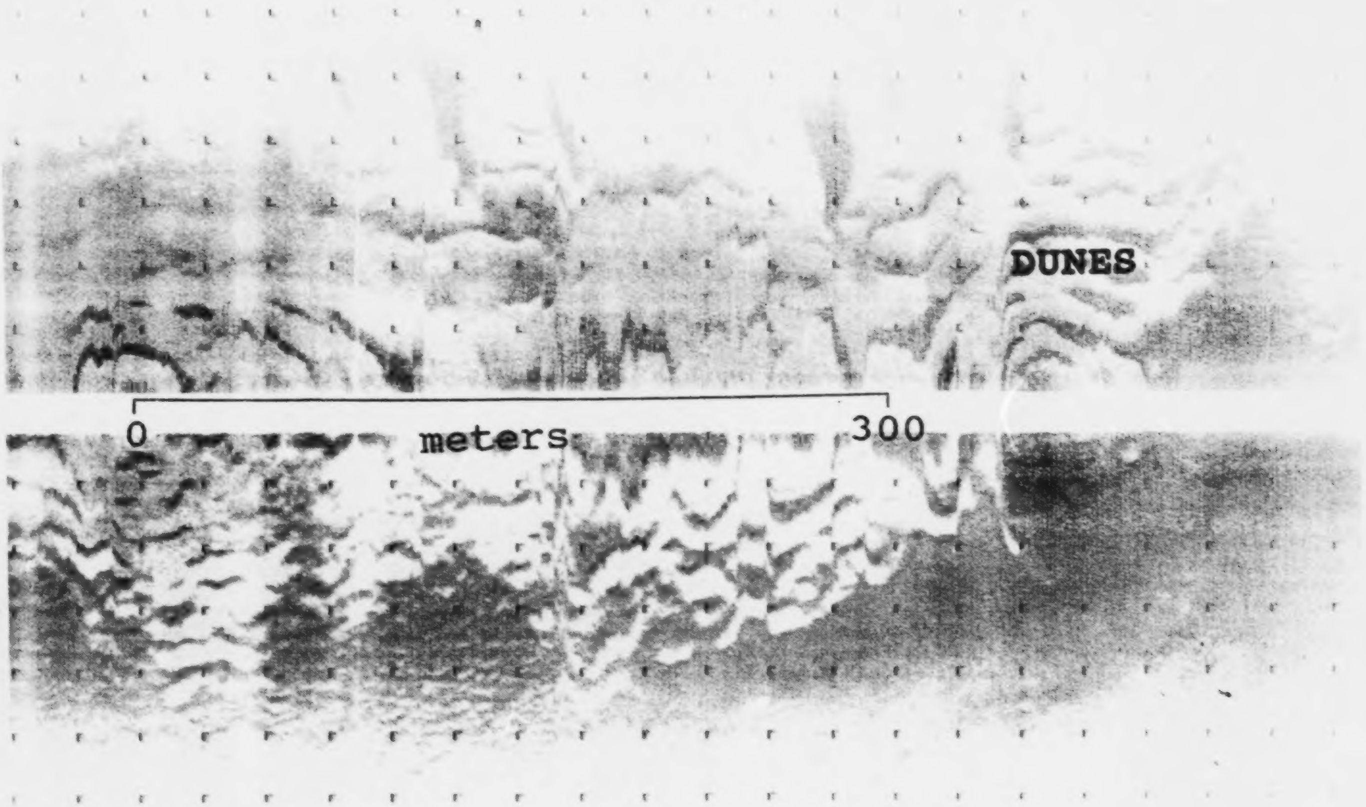

DUNES
0
meters
300

Figure 40. Side-scan sonar record of 3-D dunes on Cook Bank, Location 3 (Figure 9). Water depth is approximately 100m.

flows are channelized they may extend to water depths of 130m (Luternauer et al., 1986). Large 3-D dunes occur in water depths of up to 100 m. All of these bedforms are present in Hecate Strait, however, large oscillatory ripples are restricted to shallower water depths (<50 m) in Hecate Strait.

C. Cook Bank Cores

1. Sedimentary Facies in Cores

Five sedimentary facies were identified in the cores, two of which were subdivided into subfacies, which are summarized in Table V. Each core had a distinctly different succession of facies; there were no regionally correlatable horizons, and no single lithofacies was present in all four cores. The mineralogy of the terrigenous fraction was fairly consistent throughout all facies. Gravel was composed primarily of basalt pebbles, and minor granitic and metamorphic rocks. Sands were predominantly quartz (typically about 70%), and contained abundant heavy minerals. Barrie et al. (1988) reported that the most common heavy minerals in the surficial sediments of Cook Bank were amphibole, ilmenite and sphene.

Bioclastic Gravelly Sand (Facies 1)

This facies is composed of 50-90 % shell material, primarily bivalve and bryozoan fragments. Whole shells , especially *Glycymeris subobsoleta*, typically make up 5 to 30 % of this material. The carbonate material is white to yellowish in colour, generally coarse sand or fine gravel size, and is

Table V. Description of Sedimentary Facies

Facies	Grain Size	% $CaCO_3$	% Whole	Sedimentary Structures	Facies Contacts
1a. Massive Bioclastic Gravelly Sand	medium sand-pebble, poorly sorted	50-100	5-30	concentrations of whole-shell material	Interbedded with 1b, overlies 2 gradationally and 3b erosionally
1b. Laminated Bioclastic Gravelly Sand	medium sand-pebble, poor to moderate sorting	50-100	5-30	alternating sand and coarse shell laminae	Interbedded with 1a
2. Shelly Gravelly Sand	medium sand-pebble, poorly sorted	10-50	0-10	massive	Overlies 3a gradationally and 4 erosionally, at surface or ovln. by 1a
3a. Gravelly Muddy Sand	clay-pebble, very poorly sorted	5-20	0	massive	Gradationally overlain by 3a, lower contact unknown
3b. Muddy Sand	clay-medium sand very poorly sorted	contains one articulated shell		massive	Erosionally overlain by 1a, lower contact unknown
4. Laminated Sand	fine-coarse sand, well sorted	<1	0	fine laminations, planar(?) x-bedding heavy mineral concentrations	Erosionally overlain by 2, abruptly overlies 5.
5. Graded Sand	silt-granule, moderately to well-sorted	0-5	0	graded beds, wavy bedding, _Arenicolites_ trace	Abruptly overlain by 4, lower contact unknown.

poorly sorted. Carbonate material varies from fresh-appearing to highly bored and worn; encrustations on large shells are common. Associated terrigenous material consists of medium to coarse sand, and minor gravel. The sand is predominantly quartz with minor lithic material, and the gravel is generally well-rounded granules of basalt and minor granite.

This facies can be subdivided into a Massive subfacies (1a) and a laminated subfacies (1b). Subfacies 1a is generally massive, although whole shell material is concentrated at certain horizons (Figure 41a). Shells may show a preferred orientation (horizontal and convex-up), but commonly do not. Facies 1b consists of 1 to 5 cm thick beds of whole shell and coarse shell fragments alternating with thin laminae (less than 1cm) of medium to coarse grained sands (Figure 41b). Shells in shell layers are usually convex-up. Many of the coarse shell-beds have abrupt basal contacts and are graded, suggestive of event bedding.

Shelly Gravelly Sand (Facies 2)

This facies consists of massive, light brown gravelly sands typically containing 10 to 30% fragmented shell material, although there are higher concentrations of shell material at some horizons (Figure 42a). Whole shell valves are rare. Gravel material is primarily granule-size, but pebbles up to 5 cm are present, especially near the base of the unit. The terrigenous sand fraction is moderately to poorly sorted and typically medium grained.

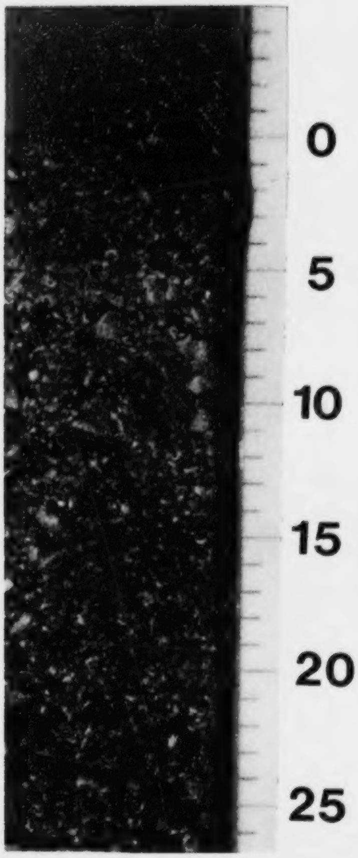

0
5
10
15
20
25

Figure 41a. Massive Bioclastic Gravelly Sand (Facies 1a). END83B-07, upper 25 cm.

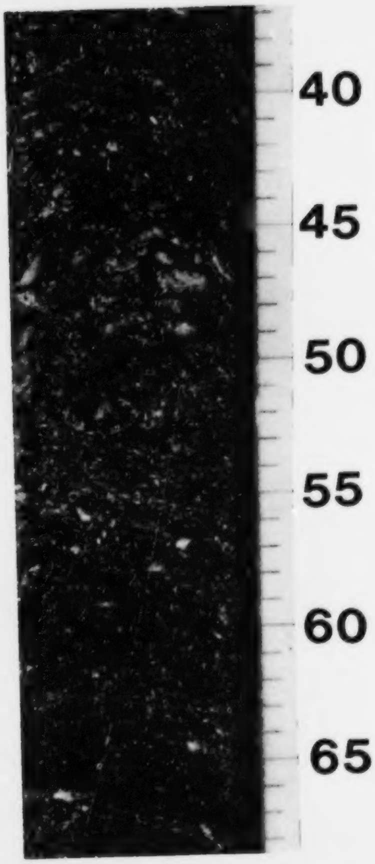

40
45
50
55
60
65

Figure 41b. Laminated Bioclastic Gravelly Sand (Facies 1b). END83B-07, 40-65 cm. Note possible event beds at 55-58 cm, 45-49 cm.

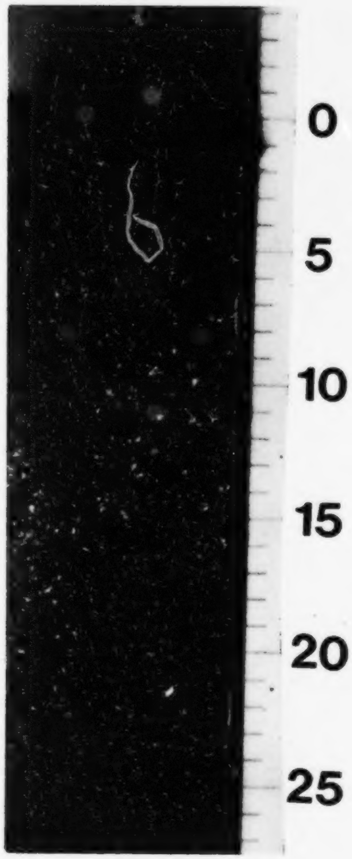

0
5
10
15
20
25

Figure 42a. Gravelly Shelly Sand (Facies 2). END83B-30, upper 25 cm.

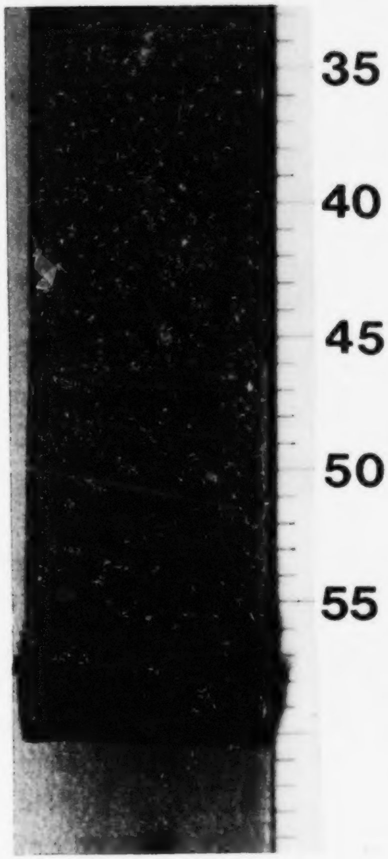

35
40
45
50
55

Figure 42b. Gravelly muddy sand (Facies 3a) below 48 cm, underlying Facies 2. Core END83B-31, 35-59 cm.

Massive Fine-Grained Facies (Facies 3)

Facies 3 contains the two subdivisions of fine grained facies: Gravelly Muddy Sand (3a) and Muddy Sand (3b). These are the only facies with appreciable silt and clay content. Facies 3a is a dark grey, gravelly, muddy sand containing abundant shell debris and lithic gravel clasts up to 3 cm in size (Figure 42b), which are sub-rounded to sub-angular. The matrix is a poorly sorted, cohesive muddy sand. Facies 3b is a dark grey, massive muddy sand containing minor shell fragments and one articulated *Glycymeris* (Figure 43a). It is dense, cohesive, and poorly sorted.

Planar-Laminated Sand Facies (Facies 4)

This facies consists of moderately to well sorted, fine- to medium-grained, planar-laminated sands. The planar laminations appear concave in the cores due to distortion during coring. The fine laminations are most easily recognizable by the dark brown or black heavy mineral laminae (Figure 43b). These laminae are concentrated in packages about 10 cm thick interbedded with equal or greater thicknesses of quartzose sands. Individual laminae range from 1 to 5 mm in thickness At several intervals within the section, single sets of planar (?) crossbedded sands about 5-10 cm thick can be seen. Divergent laminations suggestive of trough crossbedding are also seen, but may be a result of core distortion. No obviously graded beds are present, although there are occasional coarse (medium to coarse sand) laminae.

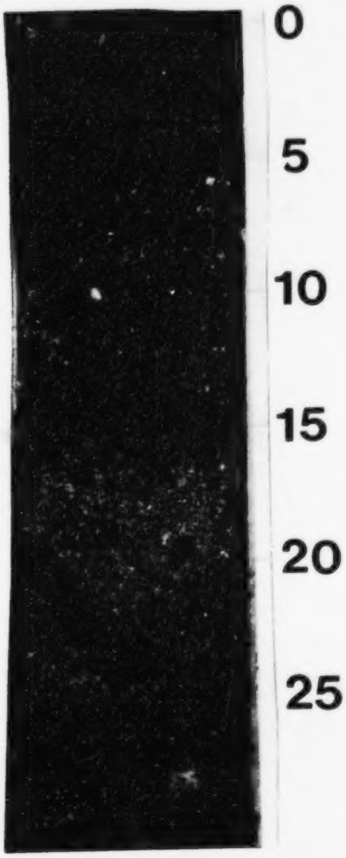


Figure 43a. Muddy Sand (Facies 3b) overlain by 1a contains articulated Glycymeris. END87B-20.

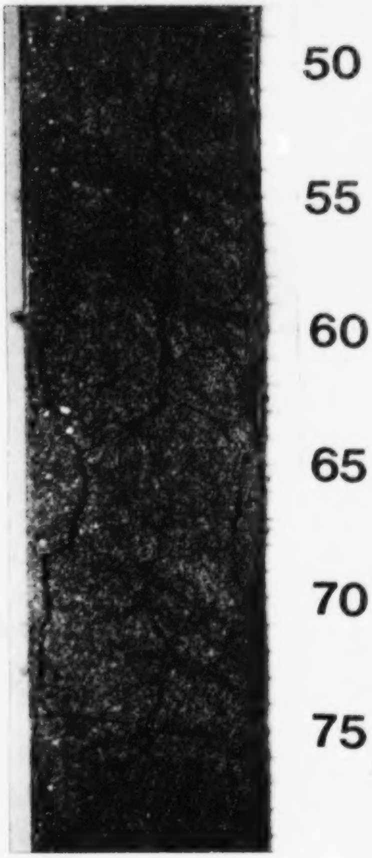


Figure 43b. Planar-laminated sand. Laminations appear concave due to distortion during coring. Cracks are a result of drying of core. END83B-30, 50-75cm.

Shell debris is present only along one side of the core, and may have originated higher in the core.

Graded Sand Facies (Facies 5)

This facies consists of a succession of normally graded beds up to 10 cm thick of light to dark brown, terrigenous sand (Figure 44). The bases of the beds are sharp and overlain by a coarse sand or fine gravel layer. The beds fine upward into very fine sands and silty sands, which are generally darker in colour. Most beds show no internal structure (apart from grading), but a few have a thin (2-3 cm) crossbed set above the basal granule layer. The silty laminae are wavy bedded, suggesting deposition during periods of low wave energy between the events that produced the graded beds.

2. Core Descriptions

Core END83B-07 was taken from a water depth of 50m in carbonate-rich gravelly sands in the northeast of Cox Island (Figure 7). The core is 1.23m long and is composed entirely of the two bioclastic sub-facies, 1a and 1b (Figure 46,47). The lower portion of the core, below 0.57m is composed of generally massive, very poorly sorted shell hash with minor sand and gravel. From 100cm to 95 cm, crude stratification is present, and this interval appears transitional between facies 1a and 1b. The section from 57 to 76 cm is distinctly finer grained, contains more terrigenous sand and is overlain by Facies 1b. The basal unit of Facies 1b, from 53 to 57 cm is

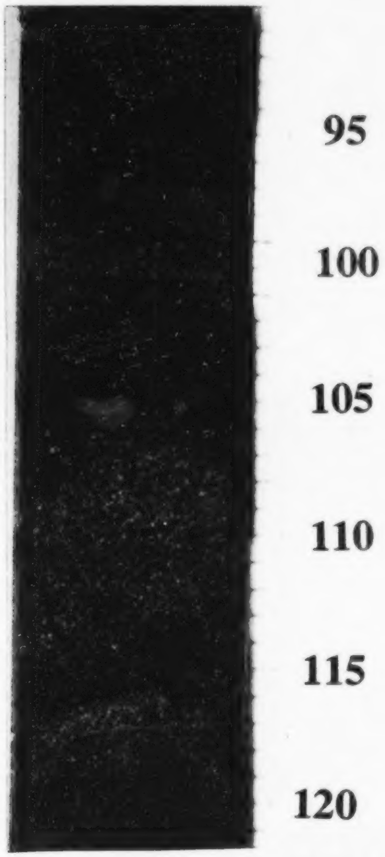

95
100
105
110
115
120

Figure 44. Graded Sand (Facies 5). Note graded bed from 105-115 cm. END83B-30, 95-120 cm.

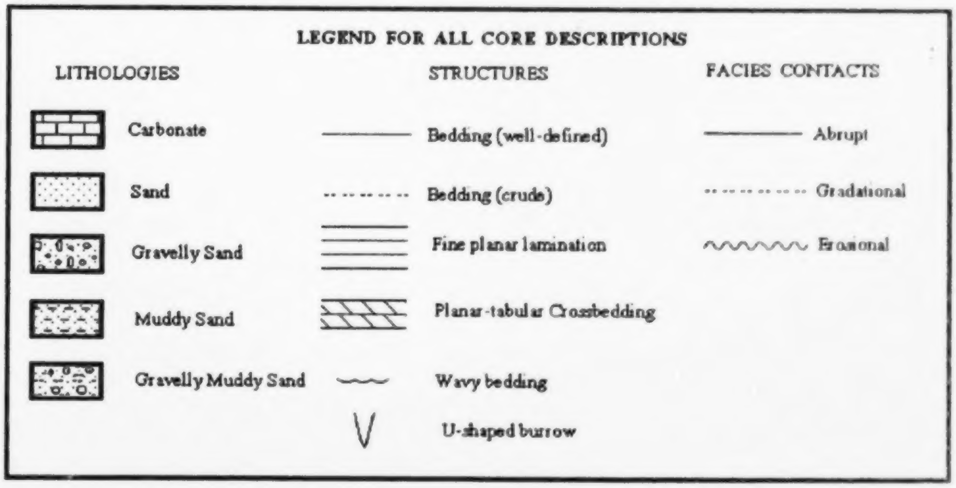
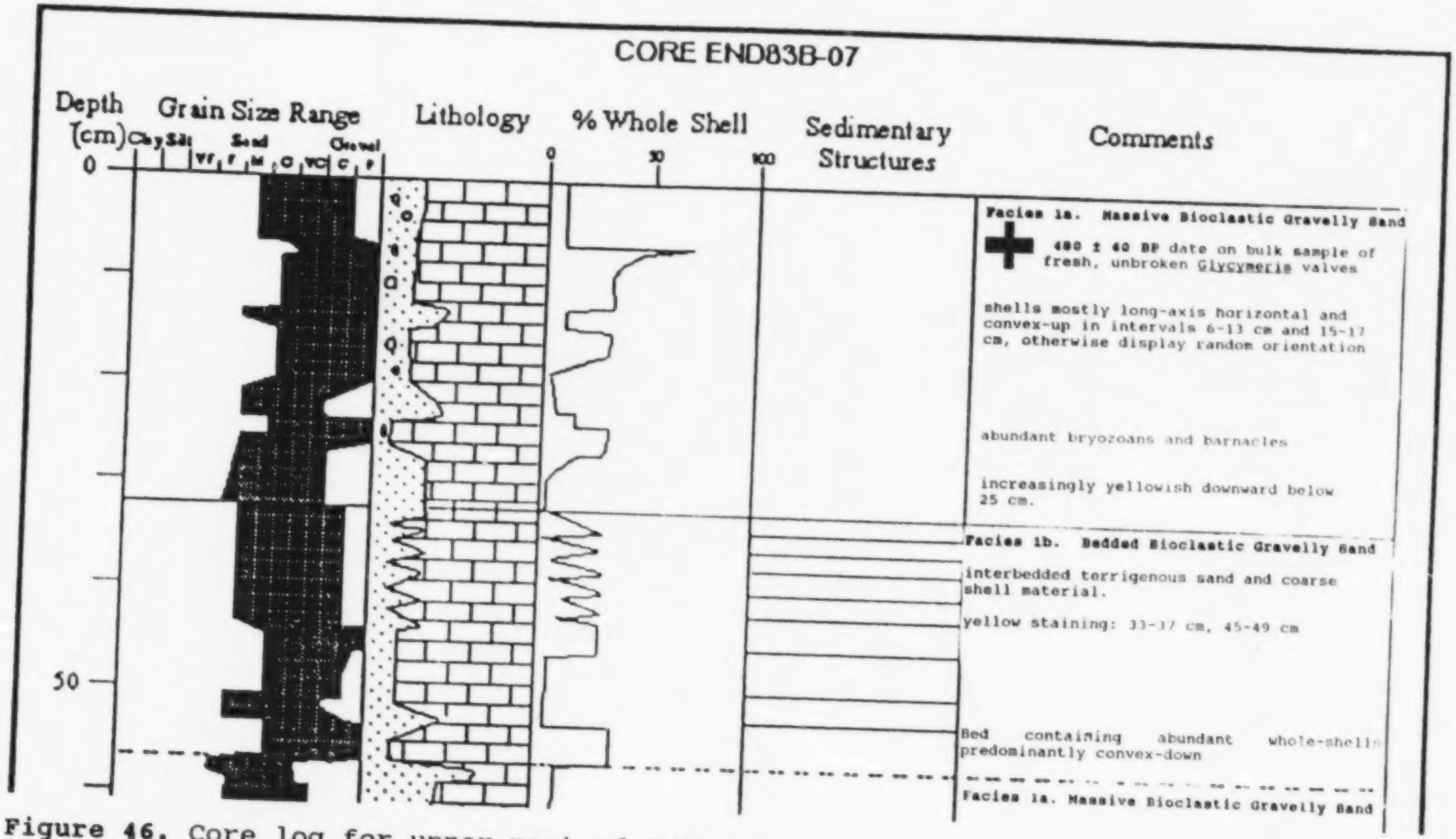

LEGEND FOR ALL CORE DESCRIPTIONS
LITHOLOGIES
STRUCTURES
FACIES CONTACTS
Carbonate
Sand
Gravelly Sand
Muddy Sand
Gravelly Muddy Sand
Bedding (well-defined)
Bedding (crude)
Fine planar lamination
Planar-tabular Crossbedding
Wavy bedding
U-shaped burrow
Abrupt
Gradational
Erosional

Figure 45. Legend for core descriptions (Figures 46-51).



Facies 1a. Massive Bioclastic Gravelly Sand

480 ± 40 BP date on bulk sample of fresh, unbroken Glycymeris valves

shells mostly long-axis horizontal and convex-up in intervals 6-13 cm and 15-17 cm, otherwise display random orientation

abundant bryozoans and barnacles

increasingly yellowish downward below 25 cm.

Facies 1b. Bedded Bioclastic Gravelly Sand

interbedded terrigenous sand and coarse shell material.

yellow staining: 33-37 cm, 45-49 cm

Bed containing abundant whole-shells predominantly convex-down

Facies 1a. Massive Bioclastic Gravelly Sand

Figure 46. Core log for upper part of END83B-07. See Figure 45 for legend.

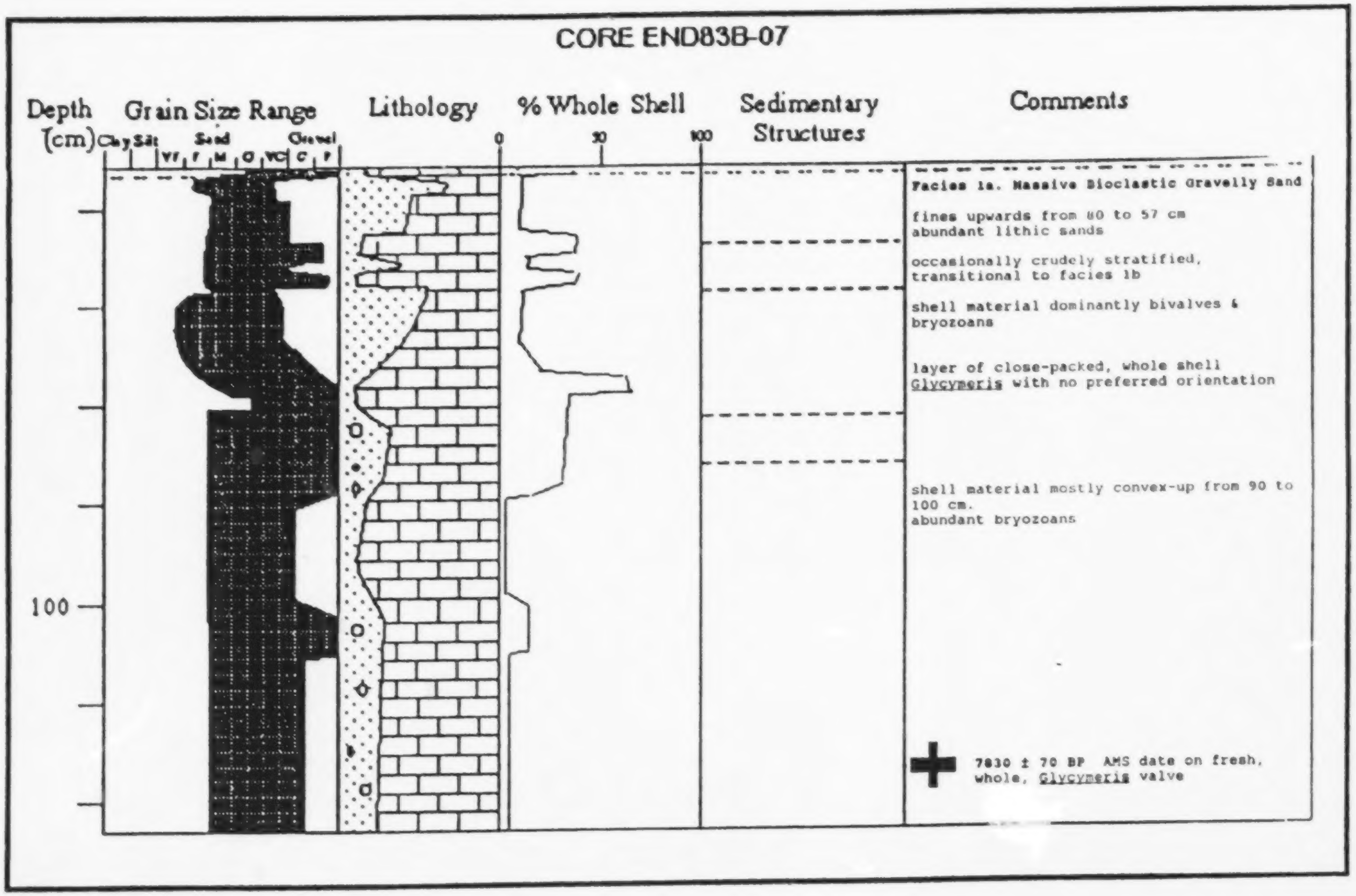


Figure 47. Core log for lower part of END83B-07. See Figure 45 for legend.

a coarse-grained, carbonate-rich interval with abundant whole shell material. Several horizons within Facies 1b are yellowish in colour. The yellow colour appears to be related to variations in moisture content in the core, possibly due to organic acids in the fluid. This interval is overlain sharply by Facies 1a, which makes up the upper 33cm of the core, and is similar to the base of the section. Within this core Facies 1a and 1b are interbedded; however, in other cores Facies 1b is absent.

Core END83B-30 is a 1.95 m long core taken from a water depth of 42m in the carbonate-poor area north of the Cook Passage (Figure 7). The lower part of the core is made up of the Graded Sand Facies (Facies 5), which is composed of a succession of normally graded beds (Figure 48, 49). Near the base of the core, at a depth of 186 to 190 cm, is a curving, mud-lined U-shaped burrow, which may be the trace Arenicolites. Apart from this trace, no other evidence of bioturbation was noted. Facies 5 is overlain abruptly by the finely-laminated sands of Facies 4. Heavy mineral laminations are not evenly distributed through the core, but concentrated in intervals 5-10 cm thick which are interbedded with quartzose layers. Facies 4 is overlain abruptly by a thin (3 cm) gravelly layer which forms the base of the Shelly Gravelly Sand facies. A large cobble 10 cm in diameter is present near the base of this unit, at 19cm, which is heavily encrusted with bryozoans and worm tubes on one side. The

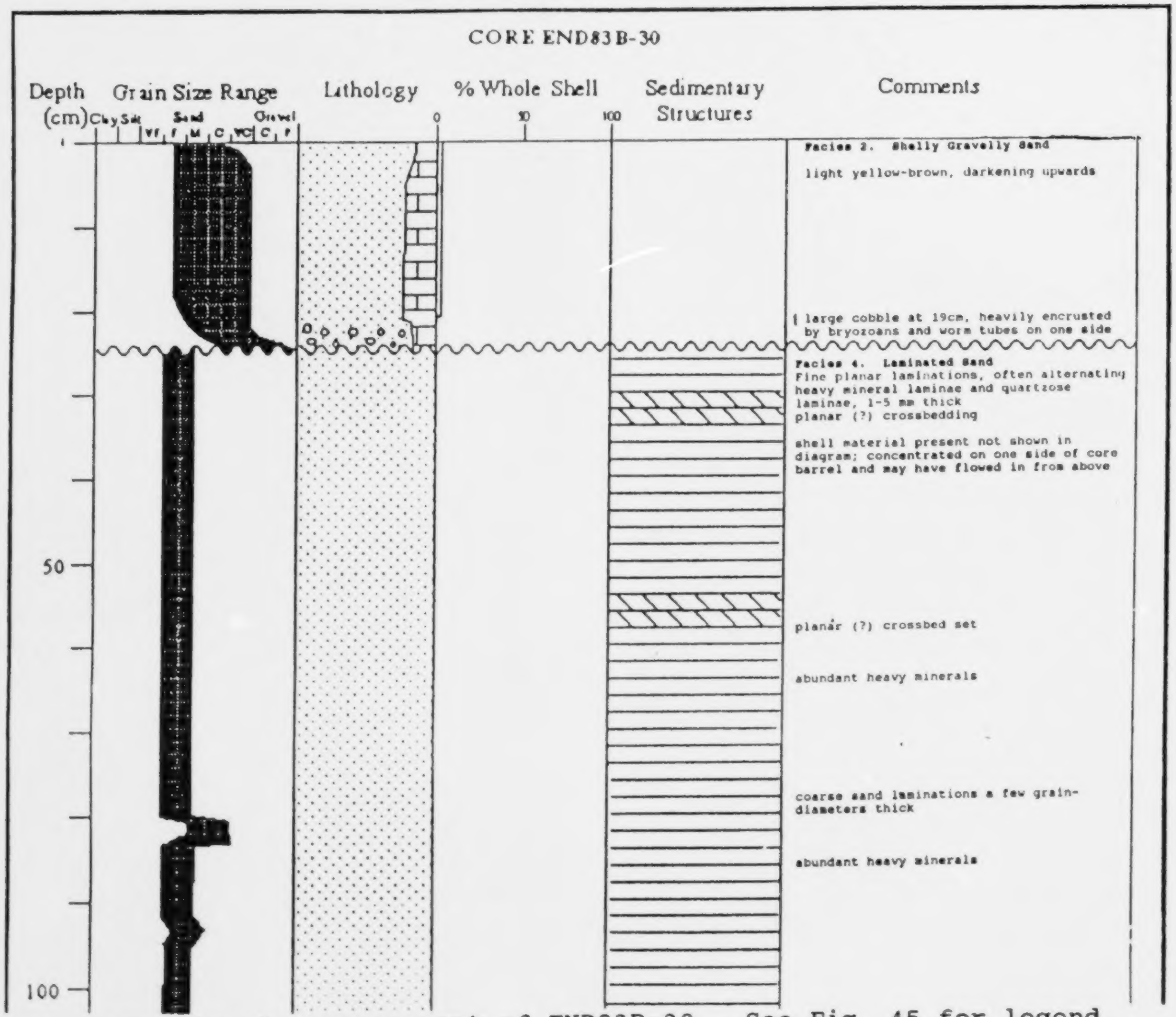

CORE END83B-30
Depth (cm)
Grain Size Range
Clay Silt
Sand VF F M C VC
Gravel C F
Lithology
% Whole Shell
0
50
100
Sedimentary Structures
Comments
1
50
100
Facies 2. Shelly Gravelly Sand
light yellow-brown, darkening upwards
large cobble at 19cm, heavily encrusted by bryozoans and worm tubes on one side
Facies 4. Laminated Sand
Fine planar laminations, often alternating heavy mineral laminae and quartzose laminae, 1-5 mm thick
planar (?) crossbedding
shell material present not shown in diagram; concentrated on one side of core barrel and may have flowed in from above
planar (?) crossbed set
abundant heavy minerals
coarse sand laminations a few grain-diameters thick
abundant heavy minerals

Figure 48. Core log for upper part of END83B-30. See Fig. 45 for legend.

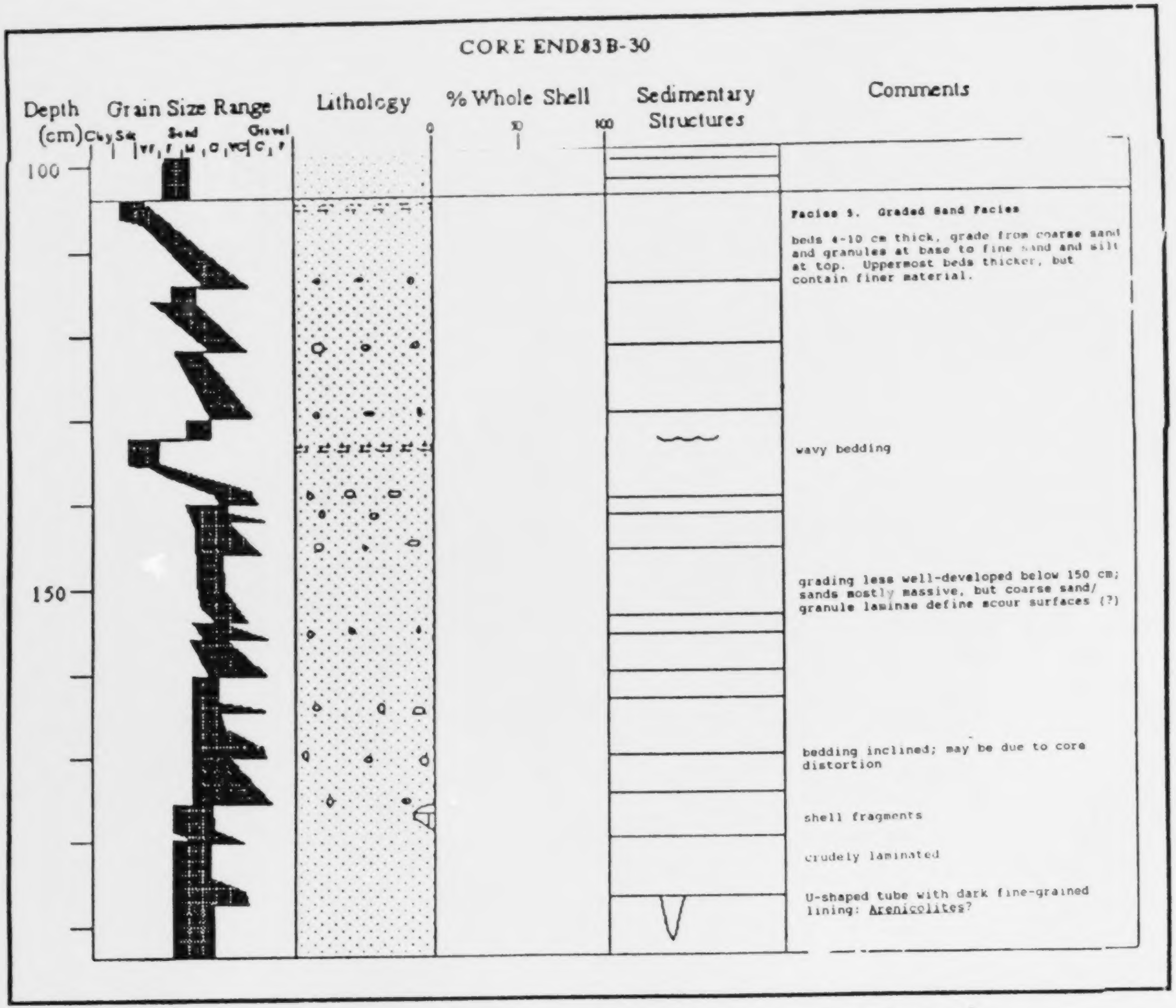


Figure 49. Lower part of core END83B-30. See Figure 45 for legend.

upper 5 cm of the core is darker in colour and finer grained.

Core END83B-31 is 0.57m in length, and was taken from a water depth of 44m in a region of high carbonate concentration to the east of END83B-30 (Figure 7). The lowest 8 cm of the core is made up of Facies 3b (Figure 50), which is gradationally overlain by Facies 2. This basal unit contains abundant (15%) shell fragments. The colour of Facies 2 lightens up core from grey to light yellowish grey, and also coarsens upwards and becomes more enriched in shell material as it grades into the overlying facies 1a. Facies 1a is a massive, light yellowish to white bioclastic unit which is fairly homogenous.

Core END87A-20 was taken from deeper water (92m) north of the Scott Islands (Figure 7), and penetrated only 30 cm into the sediment (Figure 51). At the base of the core is a 5cm thick bed of muddy sand (Facies 3a) which contains several shell fragments, and a single articulated Glycymeris subobsoleta. This is overlain by the Massive Bioclastic Sand and Gravel Facies (Ia), which tends to coarsen and become more carbonate-rich upwards to the surface.

3. Scanning Electron Micrograph Results

The samples at all cored intervals were remarkably uniform, and strongly resemble those from shallow surficial sediments in both Hecate Strait and Cook Bank. No obvious trend of increasing or decreasing degree of bioerosion,

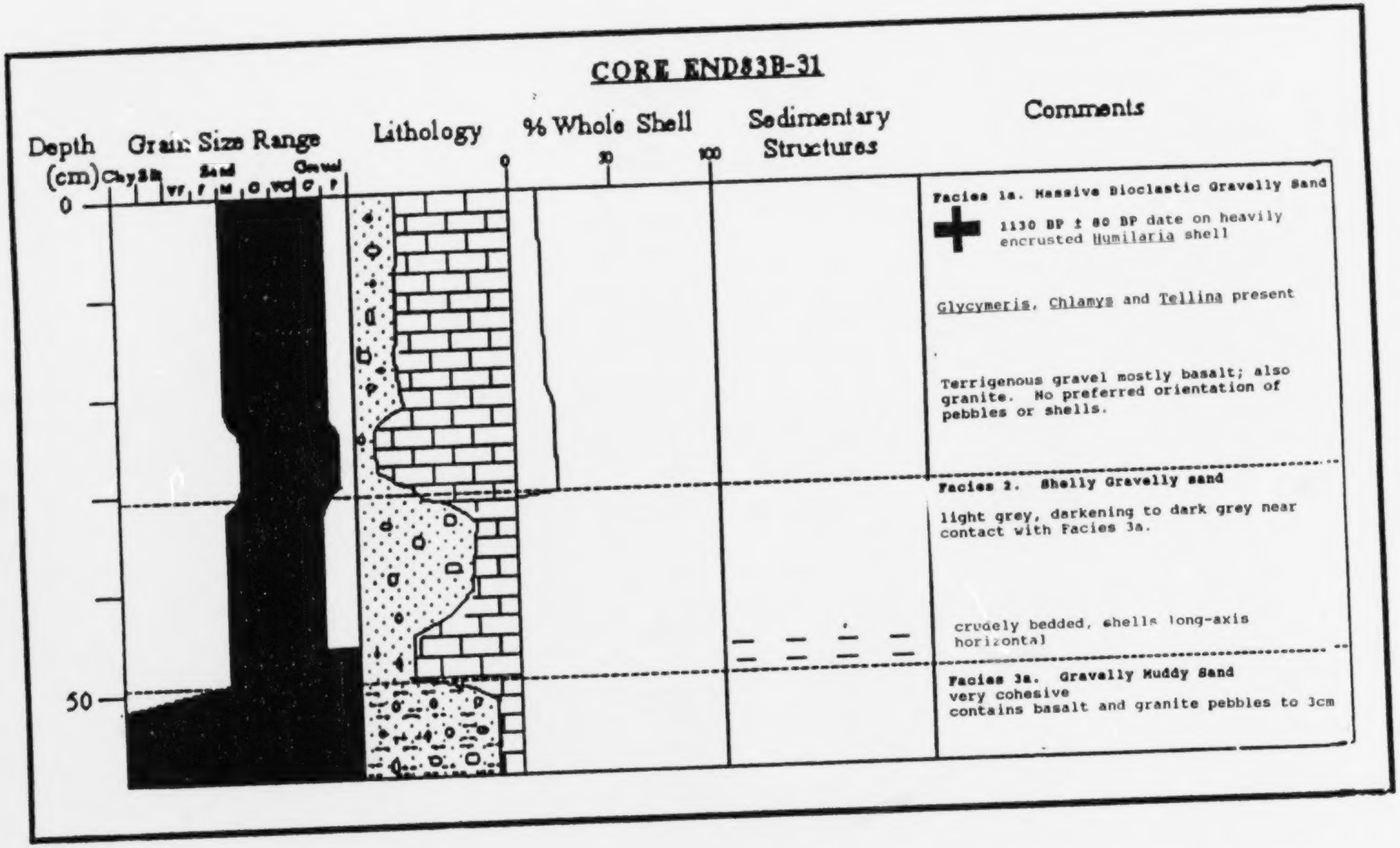

CORE END83B-31
Depth (cm)
0
50
Grain Size Range
Clay
Silt
Sand
VF
F
M
C
VC
Gravel
G
P
Lithology
% Whole Shell
0
50
100
Sedimentary Structures
Comments
Facies 1a. Massive Bioclastic Gravelly Sand
1130 BP ± 80 BP date on heavily encrusted Humilaria shell
Glycymeris, Chlamys and Tellina present
Terrigenous gravel mostly basalt; also granite. No preferred orientation of pebbles or shells.
Facies 2. Shelly Gravelly sand
light grey, darkening to dark grey near contact with Facies 3a.
crudely bedded, shells long-axis horizontal
Facies 3a. Gravelly Muddy Sand
very cohesive
contains basalt and granite pebbles to 3cm

Figure 50. Core log for END83B-31. See Fig. 45 for legend.

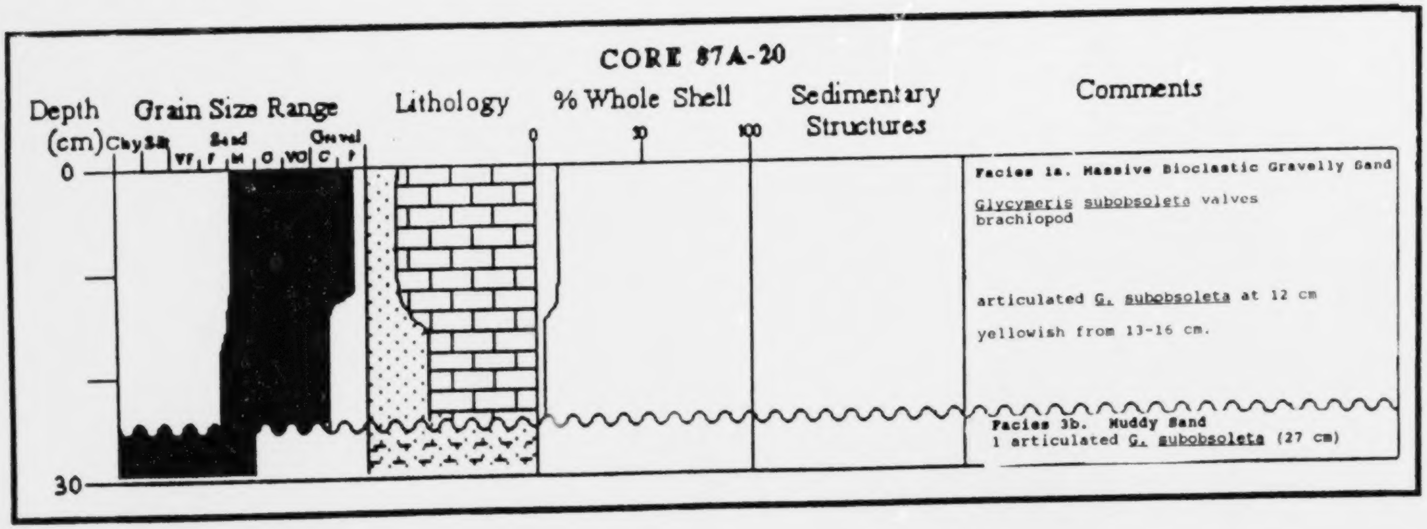

CORE 87A-20
Depth (cm)
Grain Size Range
Clay
Silt
Sand
VF
F
M
C
VC
Gravel
C
F
Lithology
% Whole Shell
0
50
100
Sedimentary Structures
Comments
0
30
Facies 1a. Massive Bioclastic Gravelly Sand
Glycymeris subobsoleta valves
brachiopod
articulated G. subobsoleta at 12 cm
yellowish from 13-16 cm.
Facies 3b. Muddy Sand
1 articulated G. subobsoleta (27 cm)

Figure 51. Core log for END87A-20. See Fig. 45 for legend.

abrasion or maceration with depth in the core could be identified.

Throughout all intervals of the core, most shell surfaces were extensively bored by a variety of boring organisms (Figure 52a,b). However, in most cases borings were restricted to the outer margin of the shell and did not penetrate deeply (Figure 53a). As in Hecate Strait, high magnification revealed that material appeared to have been lost from crystal faces, causing separation of aragonite fibres and tapering of fibre ends (Figure 53b). However, the amount of material lost through dissolution appears to be relatively minor in comparison to that lost through bioerosion.

4. Radiocarbon Dates

The oldest radiocarbon date obtained from any surficial sample from Cook Bank was 1140 BP from a corroded Glycymeris subobsoleta valve (Table V). Fresh-appearing valves all dated less than 600 BP. These dates are comparable to the dates on surficial material from Hecate Strait, with the exception of the Tellina nucleoides shells from the carbonate-poor region.

A fresh appearing Glycymeris subobsoleta valve from a depth of 118 cm in core END83B-07 dated at 7830 BP.

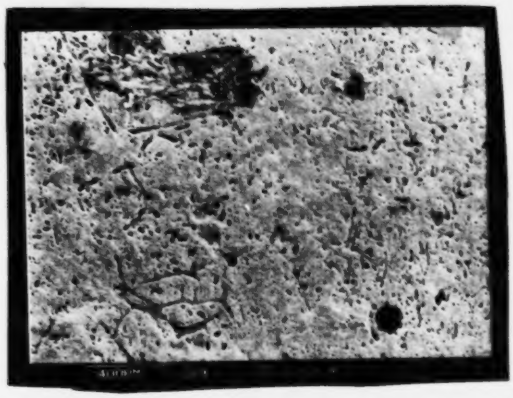


Figure 52a. Extensively bored shell surface of Glycymeris subobsoleta from top of core END83B-07.

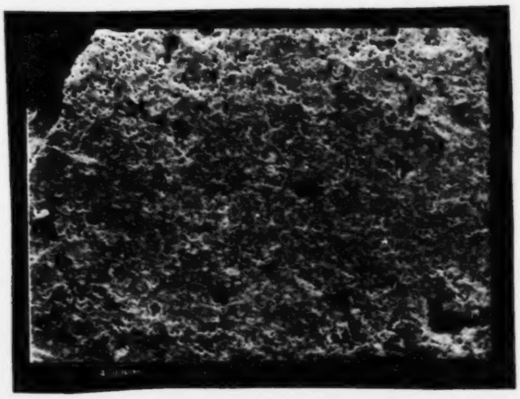


Figure 52b. Extensively bored surface of Glycymeris subobsoleta valve from a depth of 75-82 cm in core END83B-07.

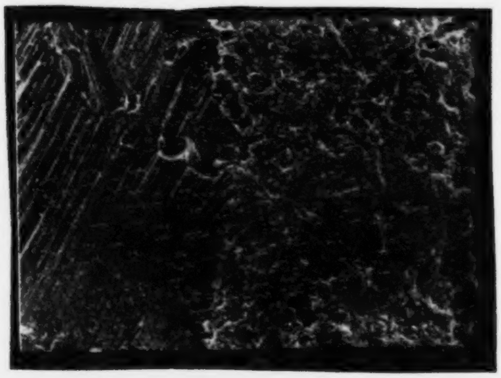


Figure 53a. Edge shot of shell from a depth of 100 to 102 cm in core END83B-07. Note that the surface (right) of valve has been intensely bored, but most of the shell, as shown in the freshly broken surface (left), is untouched. Note also that the shell is being progressively etched from top of photo, revealing the prismatic shell structure.

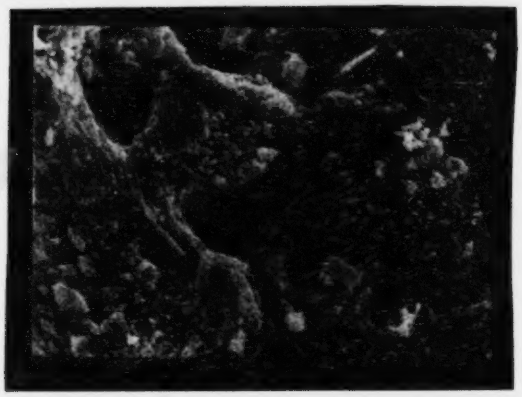


Figure 53b. High magnification (1400x) photo of shell from a depth of 100 to 102 cm in core. Note separation of shell fibres and tapered crystal terminini, caused by dissolution.

Table VI. Radiocarbon Dates for Cook Bank

Sample	Water Depth	Location/Description	C-14 yrs BP
Wk270	50	50 46.1'N 128 33.0'W fresh Glycymeris valves	220 +/-50
Wk271	50	50 46.1'N 128 33.0'W corroded Glycymeris valves	1140 +/-50
Wk272	68	50 49.0'N 128 52.4'W fresh Glycymeris valves	550 +/-50
Wk273	68	50 49.0'N 128 52.4'W corroded Glycymeris valves	1090 +/-50
Beta-40335	50	50 51.3'N 128 31.5'W fresh Glycymeris from top of core END83B-07	480 +/-60*
Beta-40336	44	50 51.5'N 128 24.2'W heavily encrusted Humilaria from top of END83B-31	1130 +/-80*
Beta-40338 ETH-7172	50	50 51.3'N 128 31.5'W fresh Glycymeris valve from 118 cm depth in core END83B-07	7830 +/- 70

*not C-13 corrected

V. DISCUSSION

A. Factors Controlling the Distribution of Carbonates

1. Distribution of Carbonate Sediments

An explanation of the distribution of carbonate sediments must account for the following observations:

1. Carbonate-rich sediments are restricted to water depths of less than 50 m in Hecate Strait and 100m in Cook Bank.
2. Carbonate sediments are closely associated with gravelly substrates.
3. Molluscan faunas in the carbonate sediments are dominated by the bivalve *Glycymeris subobsoleta*, and other molluscs preferring rocky or gravelly substrates.

These patterns could reflect carbonate concentrations produced by four different factors. These are: 1) local conditions enhancing carbonate production; 2) sediment transportation mechanisms favouring deposition of carbonates or erosion of clastics; 3) conditions favouring preservation and 4) terrigenous sediment supply. However, terrigenous sediment supply to the study areas can be considered negligible, as nearly all the terrigenous material derived from the continent is trapped in the coastal fjords (Bornhold and Giresse, 1985). The only significant sources of terrigenous sediment are the Skeena River and the fjords in the vicinity of Sea Otter Shoals (Luternauer and Murray, 1983). These sediments, however, are sufficiently fine-grained to be kept in suspension within the shallower regions of the shelf, and are deposited as muds in the deep troughs of Queen Charlotte Sound, such as Goose Island Trough.

2. Factors Affecting Carbonate Production

The only important ecological factor directly controlled by water depth is light availability, although many other factors tend to vary with depth. Ziegler et al. (1984) suggested that reduction in light intensity at high latitudes due to light reflection may be an important restriction on the latitudinal distribution of the chlorozoan assemblage. However, the only photosynthetic organisms contributing to the carbonates of the study areas are the calcareous red algae, a minor component. Thus, the correlation of carbonate content with water depth must reflect other factors which are influenced by water depth.

Food availability is an important control on any ecological community. As primary food production is negligible in benthic communities, except in very shallow water, the animals are dependent on organics settling from the surface waters (McLusky and McIntyre, 1988). Primary production is generally higher in shallow water because wave and current activity resuspend nutrients in the sediment, which would otherwise be lost from the surface waters (Postma, 1988). Strong wave and current action also produce advantageous conditions for benthic suspension feeding organisms. Strong circulation allows them to filter a larger volume of water for food, and prevents the settling of clay-size materials that increase mortality of suspension feeders (Levinton, 1982). Thus, conditions in the shallow water areas are more favourable to benthic organisms, particularly the suspension feeding organisms, such as the bivalves, bryozoans and barnacles that make up the bulk of the carbonate material in the study area. In view of the important role played by wave and tidal energy, it is not surprising that the carbonate zone extends into deeper water on Cook Bank, which experiences more intense wave action than Hecate Strait.

However, many shallow water areas, such as much of Dogish Bank and the areas adjoining Vancouver Island, are not particularly enriched in carbonate. In both study areas, sandy sediments tend to be poor in carbonate, and this is not merely a reflection of the coarse grain size of the carbonate fraction. The carbonate fraction does, on the whole, tend to be coarser grained, but it has been demonstrated that in those samples predominantly made up of gravel-size material, most of the terrigenous material is gravel-sized. Furthermore, the proportion of carbonate in the sediment shows a much stronger correlation to the regional gravel content than the gravel content of the specific sample. The faunal composition of the molluscan material in the high carbonate zone provides further evidence of a correlation between carbonates and coarse material. In shallow water areas with little carbonate material, most of the shell material is produced by the sand-dwelling species Tellina nucleoides and Olivella baetica. In contrast, high carbonate sediments contain epifaunal molluscs and infaunal organisms which are tolerant of rocky or gravelly substrates. This suggests that carbonate production may be higher within coarse-grained sediments.

This could reflect differences in the stability of the substrate. Assuming that a minimum velocity of 35 cm/s is required to move particles 2mm in diameter (Hjultrom, 1935), the predicted bottom currents presented by Barrie (1988) for Hecate Strait indicate that coarse quartz sand could be in motion 5% of the time at a water depth of 40m and nearly 1 % of the time at a water depth of 60m. In a water depth of 40m, currents would exceed those needed to move pebbles up to 5mm in diameter 1% of the time. The data of Barrie et al. (1988) for Queen Charlotte Sound suggests even greater sediment mobility: at a water depth of 40m bottom shear velocities exceed 35 cm/s nearly 50% of the time. Thus, sandy bottoms in shallow water must be very mobile. This would be an unfavourable environment for epifaunal organisms and relatively sluggish burrowing species (e.g. Glycymeris subobsoleta, Humilaria kennerlyi (Nelson and Bornhold, 1983)). Although the sediments in shallow waters adjacent to Vancouver Island are gravelly, the gravel is mostly granule-size, and may be subject to frequent motion.

Nelson and Bornhold (1983) emphasized the importance of the transition from horizontally-bedded sedimentary rock on the Vancouver Island shelf to highly deformed volcanic and sedimentary rocks in the Scott Islands region. Although rough topography and rocks with abundant crevasses and joints are more attractive to settling invertebrate larvae (Levinton, 1982), this cannot be a factor in determining the populations of infaunal bivalves. Furthermore, some of the high carbonate zone on Laskeek Bank is on a fairly flat bottom consisting of gently folded sedimentary rocks (Shouldice, 1973). This suggests that Nelson and Bornhold (1983) may have overestimated the importance of the change in bedrock character.

Upwelling of cold, nutrient-rich ocean waters may also influence primary productivity, and indirectly, benthic carbonate production. The British Columbia continental shelf does not experience the persistent upwelling that affects the west coast of the United States, but intermittent upwelling does occur on the west coast of Vancouver Island (Thomson, 1981). This may enhance the productivity of the Scott Islands area, as it is close to the shelf edge. Topographically induced upwelling can take place away from the shelf edge in areas where tidal currents are forced upward by underwater ridges and shoals (Thomson, 1981). Although the dominant tidal current near the Queen Charlotte Islands flows southward, northward flowing tidal and storm currents in this area could be forced up the steep southwestern flank of Laskeek Bank, causing periodic upwelling.

Thus, the basic pattern of carbonate sedimentation appears to be consistent with the pattern of biogenic carbonate production. High energy, shallow water areas have high rates of primary productivity and are more favourable for suspension feeding organisms. In turbulent waters, rocky and gravelly substrates provide a more stable environment than sandy substrates, and are therefore more attractive to carbonate-producing organisms.

3. Effects of Sediment Transport on Carbonate Distribution

Barrie (1988) indicated that transportation of sediment in Hecate Strait must be significant to a water depth of up to 200 m, based on current meter data and the presence of bedforms. The principal direction of sediment transport for most of Hecate Strait is to the northwest, which is the dominant direction for both wave propagation and tidal currents. Near the Queen Charlotte Islands, the dominant currents flow southward. Sediment transport should also be significant in Queen Charlotte Sound, where the dominant transport direction is toward the northeast (Luternauer, 1986).

In view of the strong currents affecting both Cook Bank and Hecate Strait, evidence of transport of the carbonate fraction is surprisingly poor. Net transport in Hecate Strait should generally be from deeper water to shallow, but faunas in Hecate Strait are rarely found in water depths shallower than their habitat. Many species in both areas are found in water depths deeper than the ranges listed by Bernard (1970). These include *Nucella lamellosa*, *Nucella emarginata*, *Nassarius mendicus*, *Diplodonta orbella*, *Spisula falcata*, *Tellina nucleoides* and *Protothaca staminea*, all of which were regarded as restricted to water depths of less than 15m. However, in a faunistic survey of Hecate Strait, Burd and Brinkhurst (1987) report many of these species in water depths of 18 to 30m, and note that *Tellina nucleoides* is the dominant species in these water depths on Dogfish Bank. The underestimates of the maximum depth distribution of these species may result from insufficient offshore samples, particularly in gravelly substrates which are particularly difficult to sample (Boyd and Brinkhurst, 1987). Furthermore, the strong current action in the study areas may produce ecological conditions similar to those prevailing in much shallower depths in more protected locales. Thus, these faunal assemblages do not necessarily imply transport, and there is no clear evidence of long distance transport of whole shell material. The inconsistency of the depth ranges may account for the poor correlation between Shallowness Index and water depth, although the very deep water (145m) occurrence of a Class I faunal sample, suggests a relict sediment at that location.

Nelson and Bornhold (1983) felt the extreme local variation in carbonate indicated minimal sediment transport, although hydrodynamic processes may actually account for the wide local variations in calcium carbonate content of the sediment. Yorath et al. (1979) reported that coarse carbonate material was concentrated in the troughs of oscillatory ripples on the Vancouver Island continental shelf, while terrigenous sands composed the crests of the bedforms. Thus, wide variations in carbonate content could be expected depending on whether the bottom sample is from the crest or trough of a bedform.

One might expect the distribution of carbonate in the sand fraction to reflect the dominant direction of sediment transport. If this were the case, carbonate content should increase sharply on the upcurrent side of the producing area and have a long trailing "shadow" of high carbonate material to the lee side. However, this is not generally true.

The paucity of evidence for long distance transport to areas in lee of the major carbonate producing zones is surprising. Sand and gravel ribbons in the southern North Sea, morphologically similar to those in the study areas, were described by Kenyon (1970). They are located on bedload transport paths between areas of erosion and areas of sandwave development. However, in the southern North Sea, the dominant tidal currents flow from a constricted shallow water area (English Channel) into less constricted, deeper water area, leading to decreasing flow conditions. The sand ribbons of

Hecate Strait form in the opposite circumstances, as the dominant currents flow into an increasingly narrow, shallow strait. Furthermore, the sand and gravel ribbons in the southern North Sea are covered with current-generated bedforms. Although the mean significant wave height in Hecate Strait in summer is only 1.1 m (Dept. of Fisheries and Oceans, 1991), sidescan sonar surveys made in summer reveal that the shallow banks are covered with oscillation ripples, implying that these ripples must form through wave processes. If so, they are not reworked by the semi-diurnal tidal currents, indicating that the gravel ribbons are either created by modern, storm-generated currents or are relict from a lower sea level stand. As the ripple crests are generally not quite perpendicular to the ribbons, the latter alternative seems most likely.

Nelson and Bornhold (1983) attributed the lack of extensive transport of the carbonate sediments on Cook Bank to sediment trapping by the complex topography. However, this cannot account for the localized occurrences of carbonates in Hecate Strait, where the shallow bank areas are fairly flat. The storm-generated currents may be too infrequent to have moved large masses of sediment long distances during the Holocene. An alternative possibility is that large amounts of sediment are transported, but that carbonate material is preferentially removed through shell degradation.

terrigenous sediments are abundant. The increased rate of abrasion in such areas may partly account for the absence of abundant carbonate sands leeward of the major carbonate producing zones.

The third major process causing shell degradation is dissolution. It is unknown whether there are significant differences in carbonate saturation of sea water in different areas of the shelf. However, as the rate of dissolution is inversely related to grain size (Kerr, 1980; Walter and Morse, 1984), fine-grained carbonate may be preferentially leached. The rate of dissolution on the British Columbia continental shelf is difficult to estimate, but it is possible that differential solution of fine carbonate material may be another factor which reduces the amount of carbonate outside the carbonate-producing regions. Dissolution of aragonite may account for the extraordinarily high calcite contents (>95%) of carbonate sands from the nearby Alexander Archipelago reported by Hoskin and Nelson (1969). They regarded the presence of fine aragonite needles in the sediment as incompatible with significant dissolution. However, Alexandersson (1979) reported that aragonitic fibres were common in the mud fraction from the Danish Skaggerak, and that they were derived from disintegration of mollusc shell fabrics caused by dissolution. Thus, the presence of these needles may actually reflect dissolution processes.

4. Destruction of Carbonate Material

A striking characteristic of shell material from both Hecate Strait and Cook Bank is the intensity of the processes of shell degradation. Bioerosion is the single most important process, because it not only removes material directly, but also contributes to abrasion and maceration by weakening the shell.

Young and Nelson (1988) report that the most important bioeroders are cyanophytes, green algae, red algae, fungi, bacteria and clionid sponges. Macroborers such as predatory and grazing gastropods are also very important. As the cyanophytes and algae are light-dependant, it is unsurprising that the deep water samples from Hecate Strait appear to have suffered less intense microboring. In spite of the greater rapidity of skeletal destruction in shallow water, the carbonates were found primarily in shallow water, suggesting that the spatial distribution of carbonate controlled more by biogenic production than biogenic destruction.

Even within the carbonate-rich zones, less than 20% of the material is made up of whole valves, which attests to the importance of breakage and abrasion during transportation. These processes should be most active in those areas experienceing the greatest movement of sediment: shallow water, exposed areas of relatively fine-grained sediment. As calcite and aragonite are much softer than quartz or most lithic fragments, abrasion should occur more rapidly where

B. Geological History of the Study Area

1. Interpretation of Cook Bank Cores

Core END83B-07

This core is principally composed of the Massive Bioclastic Sand and Gravel facies (1a), which also makes up the surficial material (Figure 46,47). The radiocarbon date of 7830 BP from near the base of the core, combined with the high carbonate content throughout the core, indicates that conditions at this locale have been favourable to carbonate deposition for at least 7500 years. Layers enriched in whole shell material are often dominated by convex-up valves, suggesting current depostion by major storm events. The stratified facies 1b may have resulted from a period of more frequent storm activity. An alternative explanation may be the the migration of large oscillatory ripples, if the coarse shell laminae represent the troughs of the bedforms. However, in view of the slow rate of aggradation (the mean sedimentation rate over the Holocene, calculated from the dates in these cores is approximately 15cm/1000 years), it seems unlikely that these laminae could represent the passage of individual bedforms.

Core 83B-30

In contrast to END83B-07, this core is dominated by sediments which reflect a depositional regime distinctly different from the modern conditions (Figure 48,49). The graded beds imply events of declining flow regime; in the study area, the most likely cause is storms, although no laminae strongly suggestive of hummocky cross stratification are present. Silty laminae associated with periods of quiet water are unusual, which probably reflects amalgamation of storm beds by frequent storm events. Silt laminae are wavy laminated by weak wave activity between storms. Shell material in this succession is rare, indicating an abundant source of sand, probably from the reworking of till or glaciofluvial sediments. The predominance of graded storm beds is suggestive of an environment in the lower shoreface. The trace Arenicolites is typically made by low-level suspension feeders, and is most common in shallow water below fair-weather wave base (Dorjes and Hertweck, 1970), which is consistent with a lower shoreface interpretation for the unit.

The fine planar lamination of the overlying facies 4 suggests upper flow regime processes of deposition. Planar laminated sands with isolated crossbed sets are common in swash zone sediments (Elliott, 1986), as are heavy mineral concentrations on Oregon beaches (Clifton et al., 1971). In view of the proximity to lower shoreface sediments, it could also be interpreted as upper shoreface, as the low angle trough-crossbedding which typifies this environment (Elliott, 1986) is difficult to recognize in core.

The uppermost facies in the core is a gravelly shelly sand with a gravelly base, which may be an erosional lag (Figure 49). No whole shell material was present, suggesting that the shell material is transported, possibly from the carbonate-rich zone. This facies is massive and homogenous, which may reflect bioturbation.

In summary, this core documents an abrupt shift from lower shoreface conditions to foreshore or upper shoreface conditions, followed by a period of erosion. After the erosional phase, the present depositional regime was established. If the planar-laminated sands originated in the foreshore, this implies a disconformity between these sands and the underlying graded sands, as would be produced by a forced regression caused by a fall in relative sea level. Even if these sands are upper shoreface, the change from lower shoreface to upper shoreface over a short interval is unlikely to be a result of sediment supply driven progradation, and suggests a fall in sea level. Within the context of a prograding shoreface section, the overlying erosion surface is best explained by subaerial exposure.

Although no material from the core could be dated, the area would have experienced rapid regression and subaerial erosion shortly after deglaciation, due to isostatic rebound. The lower part of this core probably represents a prograding shoreface deposited in the late Pleistocene. It is surprising that the foreshore (or upper shoreface) sediments survived exposure. The sands may have been colonized by terrestrial vegetation during the low-stand which reduced the amount of erosion during the subsequent transgression, although the overlying terrestrial soil was eroded. The presence of a late Pleistocene paleosol on Cook Bank at 91 m water depth (Luternauer et al., 1989) indicates that it is possible for terrestrial sediments to survive a transgression.

When the area was subsequently transgressed in the Holocene, the sandy sediments were too unstable for the establishment of a large carbonate-producing benthic population.

Core END83B-31

The lowest 8cm of this core are a cohesive gravelly muddy sand (Figure 43b). Modern sediments on the shelf in water depths this shallow do not contain nearly as much fine-grained material. The very poor sorting suggests a glacial origin for this unit, but no erosion surface representing the period of exposure in the Late Pleistocene can be recognized. Perhaps the mud fraction was derived from underlying glacial-marine sediments as rip-up clasts. Above the muddy bed, the sediments become increasingly carbonate-rich from 51 cm to 43 cm within the lower part of the Gravelly Shelly Sand Facies. The uppermost 31 cm is composed of bioclastic sediments similar to that in core END83B-07, which reflects the modern environment.

Following the cessation of terrigenous sediment supply, and continuing accumulation of shell material, the Wilson (1988) model predicts a gradual increase in carbonate over time. This model appears to hold for core END83B-31. Furthermore, the addition of coarse shell material causes an increase in grain size, providing a substrate for epifaunal organisms and favouring increased biogenic carbonate production. The process by which the accumulation of skeletal parts favours an increase in skeletal part production has been termed taphonomic feedback (Kidwell, 1986). The relative scarcity of whole shell material in Facies 2 suggests that much of the carbonate material was probably derived from outside the immediate area. However, whole shell material is fairly common in the upper 30 cm of the core. Core END83B-31 is probably taken from a location which was initially carbonate poor, but in which the addition of coarse, shelly material has created a more favourable substrate for carbonate formation.

Core END87A-20

The lowest 5cm of core END87A-20 is a cohesive muddy sand. In view of the sharp contact with the overlying unit, and the absence of similar Holocene sediments in comparable water depths, it is likely that this muddy sand was deposited prior to exposure, during the late Pleistocene. The presence of an articulated (though probably not in life position) bivalve and poor sorting suggest a marine or glacial-marine origin. Above the sharp contact at 25cm the sediments are increasingly carbonate-rich upward, which is similar to the pattern of core END83B-31. As these sediments are deposited subsequent to the low stand, they are interpreted as Holocene.

Summary

Two of the cores contain sediments interpreted as pre-Holocene beneath an erosional surface representing subaerial exposure. In core END87A-20 the late Pleistocene is represented by glacial-marine sediments, while the other appears to represent a prograding shoreface. The Holocene section in the cores ranges from 24 cm to at least 120 cm in thickness, and in two cores carbonate content appears to have increased over time. Expansion of the carbonate-dominated area over time is in keeping with the Wilson (1988) model for evolution of temperate carbonates. In core END83B-07, the environment has been remarkably stable through most of the Holocene. Although no cores have been taken from the high carbonate region of Hecate Strait, in view of the strong similarities in sea level history, modern sediment characteristics and surficial sediment radiocarbon dates, it seems likely that any cores taken there would show similar patterns.

2. Sediment Accumulation Rates

The young radiocarbon ages for all dates from surficial sediment on Cook Bank led Nelson and Bornhold (1983) to suggest that the rapid rate of degradation prevents the survival of aragonitic bivalves for more than about 1000 years. The old shells in core END83B-07 do not necessarily contradict this assertion, as they may have been carried into a sheltered area by storm currents and buried, and therefore not subjected to a long period of exposure at the sea floor. However, aragonitic *Tellina nucleoides* shells in Hecate Strait age-dated at more than 2000 years. This is a mean date on a large number of shells, probably indicating that a range of material from modern to several thousand years old is present. Furthermore, the shells are much smaller and thinner than adult specimens of *Glycymeris subobsoleta*, and are found in sandy sediments in water depths of less than 30m. Thus, these shells should have experienced an equal or greater rate of physical and biological degradation to the *G. subobsoleta* shells. If *T. nucleoides* can survive the rigorous conditions for a period of several thousand years, despite a relatively thin shell, *G. subobsoleta* should also be able to survive.

An alternative to the Nelson and Bornhold (1983) hypothesis is that older shells are widely present, but are buried and not subsequently reworked. *G. subobsoleta* is fairly large (typically 2-4 cm) and has a thick shell, so it is unlikely to be entrained in a flow except under intense storm conditions. However, the declining storm currents may bury the shell under the fragmentary material which makes up most of the carbonate fraction. As most of the destructive processes take place at the sediment-water interface, the buried shell is relatively protected. Similar processes may account for the survival of *T. nucleoides*. Thus, although shells exposed on the seafloor for long periods of time may rapidly degrade, many shells will not experience such extensive exposure and will accumulate. If we assume that the grab samples collect only the top 10 cm of the sediment, and that the oldest material present in the top 10 cm is 1500 years, a mean sedimentation rate of 7 cm/1000 years is calculated. This would result in a Holocene sedimentary package less than 70 cm thick.

This sediment thickness is not incompatible with the apparent thickness seen geophysically. Nor does 7 cm/1000 years represent unrealistically rapid accumulation in a highly destructive environment; Farrow et al. (1984) estimate that the mean sedimentation rate on the Orkney Islands platform edge exceeds 30 cm/1000 years. This is particularly interesting because the carbonates of this region are similar to those of British Columbia. The carbonates from the zone of maximum productivity consist of a mixture of infaunal bivalves (especially Glycymeris glycymeris), and epifaunal debris. The bulk faunal composition is 51% bivalves, 16% barnacles, 16% bryozoans and 7% foraminifera, very comparable to the figures reported by Nelson and Bornhold (1984) for Cook Bank. A carbonate sedimentation rate of 5-10 cm/1000 years is therefore fairly slow in comparison with the best modern analog, and is not inconsistent with the high rates of carbonate destruction which appears likely for the shelf. Thus, it appears that these sediments are probably slowly accumulating throughout the carbonate-producing regions of the shelf, and that the older shell material found in the terrigenous sediments reflects the low rate of carbonate production in that area. Sedimentation rates show considerable local variation, however, as the relatively rapid rate of 15cm/1000 years calculated from core END83B-07 shows.

3. Geologic Controls on Carbonate Sedimentation

The factors which favour the development of temperate carbonates in both study areas are largely a result of the Pleistocene and early Holocene geologic history of the British Columbia continental shelf. Two principal, and related, geological processes have shaped the modern surficial sediment distribution: glaciation and sea level change.

The extent of the Late Wisconsinan glaciation in the study areas is unclear; however, it is known that all of Hecate Strait and Queen Charlotte Sound were glaciated during the Pleistocene, and that Queen Charlotte Sound was ice-free by 15000 BP (Luternauer and Murray, 1983; Barrie and Bornhold, 1989). This glaciation deposited tills and glacial-marine sediments containing abundant coarse material. In the shallow water areas, winnowing of these glacial sediments has produced the poorly sorted sandy gravel which is the predominant terrigenous sediment in many areas. During glacial retreat, sandy glaciofluvial and outwash sediments were produced which may be the principal source of well-sorted sands in the area. Other sands may be derived from the transportation of sediments winnowed from tills.

Following deglaciation, both study areas experienced a low stand in sea level at about 10500 Ka (Luternauer et al., 1989), and consequently, subaerial erosion. Nearly all the sediment in water depths above 75m was removed during this time, leaving abundant bedrock outcrop and a gravel lag derived from the preexisting till and the local bedrock. The falling sea levels immediately prior to this low stand also produced the progradational shoreface in core END83B-30. Furthermore, the rise in sea level trapped terrigenous sediments in the fjords, reducing clastic input to the shelf. Thus, glaciation, subaerial erosion and transgression produced the conditions required for extensive carbonate sedimentation on the British Columbia continental shelf.

The patterns of sediment distribution in the shallow water areas of Hecate Strait and Cook Bank can generally be explained through an examination of their geologic history. In Hecate Strait, Dogfish Bank differed from Laskeek Bank in the abundance of terrigenous sands. In view of the very low carbonate content of these sands it seems unlikely that they have been principally derived from the carbonate-rich sediments to the south. The presence of abundant plutonic material derived from the Coast Range on the gravelly eastern part of Dogfish Bank is striking. Curiously, the proportion of plutonics does not show a steady decline with distance from the Coast Range. Instead, it is relatively low in the deep water areas, high on eastern Dogfish Bank, and declines again to the west. The low values from the deep waters nearest the coast range may reflect derivation from a basal till. As basal tills are derived from the base of the glacier, they tend to contain more locally derived material than tills derived from englacially transported material. Ablation and flow tills contain englacially transported material (Sugden and John, 1976), that may be transported long distances (Haldorsen et al., 1989). Thus, the gravels on eastern Dogfish Bank may be derived principally from englacially transported material from an ice-marginal environment or a stagnant body of ice. The well-sorted sands to the east on Dogfish Bank may have originated as outwash sediments, although subsequent reworking has probably affected their distribution. In view of the limited extent of glaciation in the Queen Charlotte Islands (Clague et al., 1982), much of Hecate Strait may have been ice free during the Wisconsinan. The gravels on Dogfish Bank may be a remnant of a lateral moraine of the Cordilleran ice sheet, as it would likely have flowed southward down the axis of the strait, following the topography. Another extensive sand body roughly parallels the bathymetry along the eastern edges of Dogfish and Laskeek Banks (Figure 17) in water depths of 50 to 100 metres, possibly reflecting old shorelines. Moslow et al. (1989) interpreted sand ridges in this region as relict near-shore ridges with modern analogues in water depths of 15-20 m on

Dogfish Bank.

On Cook Bank, there is a general trend from gravelly sediments in shallow water, to sands at intermediate depths (75-150 m) and muddy sands in deep water. The principal exceptions to this are sandy sediments in the topographically complex Scott Islands region, which probably reflect local sediment transport patterns, and a sinuous linear body of sandy gravel extending northward from Sartine Island toward the confluence of Cook Trough and Goose Island Trough (Figure 36). Luternauer and Murray (1983) interpreted features in the latter area as morainal and ice-contact landforms, which suggests that the gravel body could have resulted from reworking of the same moraine complex.

C. Temperate Carbonates and the Geologic Record

1. Preservation Potential

Geologic and oceanographic conditions on the continental shelf of British Columbia during the Sangamon interglacial may have resembled those prevailing during the Holocene. However, all material dated was Holocene, and no cemented grains reworked from preexisting carbonates (intraclasts) are present. The absence of carbonate material from previous interglacials suggests that the preservation potential of carbonates deposited during these periods may be very poor.

Assuming that Milankovitch-forced glacial-interglacial cycles continue, interglacial conditions will last approximately 20,000 years (Pelletier and Hyde, 1984; Pollard, 1984; Aharon, 1984) and will be followed by subaerial exposure and potentially, glaciation.

Assuming the current interglacial lasts 20000 years and carbonate sediments are deposited at a rate of 5-10 cm/1000 years, a mean sediment thickness of 1-2 m would be deposited prior to exposure. The resulting deposit would be a thin, discontinuous blanket with greater thicknesses in topographic lows.

Cementation

Submarine cementation is unusual, though not unknown, in temperate carbonates. Holocene inorganic cementation in beach and subtidal environments occurs in the Mediterranean (Alexandersson, 1969), and is interpreted from the Miocene in Australia (James and Bone, 1991). Direct cementation in waters which are sometimes undersaturated with respect to calcium carbonate is unlikely, although Alexandersson (1974) found that biologically-induced cementation occurred within red algal nodules, even in undersaturated waters. Carbonate precipitation is widely reported in association with methane seeps (e.g. Jorgensen, 1976; 1992; Nelson and Lawrence, 1984; Hovland et al., 1987). However, these occurrences are generally from organic-rich muds where the poor permeability of the sediment produces anoxic conditions near the sediment water interface. The sediments in Hecate Strait are well-oxygenated and very poor in fine-grained organics, and are unlikely to experience methane-related cementation. Thus, environmental conditions on the British Columbia continental shelf do not appear favourable for submarine cementation of the carbonates, and it has not been observed.

The effects of subaerial exposure on unconsolidated temperate carbonates are not well understood, but are not necessarily destructive. Collins (1988) reported variably cemented Pleistocene calcarenites on the inner shelf of southwestern Australia and surfaces of Pleistocene carbonates in southern Australia are calcreted (Gostin et al., 1988). Some Pleistocene raised beaches in England are carbonate cemented (West, 1973) and incipient cementation has been reported from the Holocene (Merefield, 1984). In contrast, some Australian temperate carbonates are still poorly cemented after several million years of exposure (Reeckman, 1988), and cementation of some New Zealand carbonates was minimal until burial depth exceeded 600m (Nelson et al, 1988a). Slow rates of cementation under meteoric diagenesis in temperate carbonates are generally attributed to the predominance of calcite over aragonite (Nelson et al., 1988b; Reeckman, 1988; James and Bone, 1991). Despite the effects of marine dissolution, the carbonates in the study areas contained abundant aragonitic bivalve material, and might, therefore, be expected to behave more like the English examples, which are estimated to have originally contained about one third aragonite (West, 1973). Cementation under subaerial conditions could significantly modify the faunal composition of the sediments; West (1973) estimated that 25% of the sediment had dissolved to form the cements, removing most of the aragonitic material. Thus, the carbonates from Hecate Strait and Cook Bank would lose much of their mollusc content, and the fossil record would be relatively enriched in bryozoans and barnacles. The raised beaches studied by West (1973) were largely cemented under periglacial conditions and buried by solifluction debris. If these beach sediments are from the last interglacial, this represents more rapid loss of aragonite than was experienced by temperate carbonates in Australia (Reeckman and Gill, 1981). West (1973) attributed the rapid diagenesis to the high solubility of carbon dioxide in cold water and a high water table. As climatic conditions in modern England are similar to those in coastal British Columbia, it seems possible that similar conditions could exist during a glacial interval. Assuming the diagenetic characteristics of the English raised beaches are an appropriate analog, subaerial exposure during a glacial episode would result in cementation, although there would be a significant loss in thickness. If buried by terrestrial sediments, they would probably lose about 20% of their total thickness through compaction (West, 1973), otherwise they would experience subaerial erosion. Sediments deposited in topographic lows would have the best preservation potential.

Effects of a Subsequent Regression and Glaciation

An advance of glacial ice over this deposit would probably destroy it and mix it with terrigenous material, as it would be thin and relatively soft, although some of the material might survive in bedrock lows. This may have been the fate of any Sangamon carbonates deposited in British Columbia. A less extensive glacial advance, however, could facilitate preservation by burying the carbonates with proglacial outwash or, if isostatic depression inundates the previously exposed carbonates, glacial-marine sediments.

Glacial retreat and the ensuing marine transgression would rework any overlying sediment, whether it is solifluction debris, proglacial outwash or glacial marine sediments, into a gravel lag. This lag could incorporate cemented carbonate and Tertiary bedrock eroded from the underlying sediment, as well as the winnowed unconsolidated material. This gravel lag would provide suitable conditions for renewed carbonate sedimentation during the subsequent high stand in sea level.

Although no preexisting Pleistocene carbonates from the regions are known, there is some potential for preservation. If a series of interglacial carbonates were preserved by the processes outlined above, the resulting section would be a discontinuous planar body of thin-bedded skeletal grainstone (Figure 54a). The bedding planes would be subaerial karst surfaces, scoured and reworked during the transgression, and

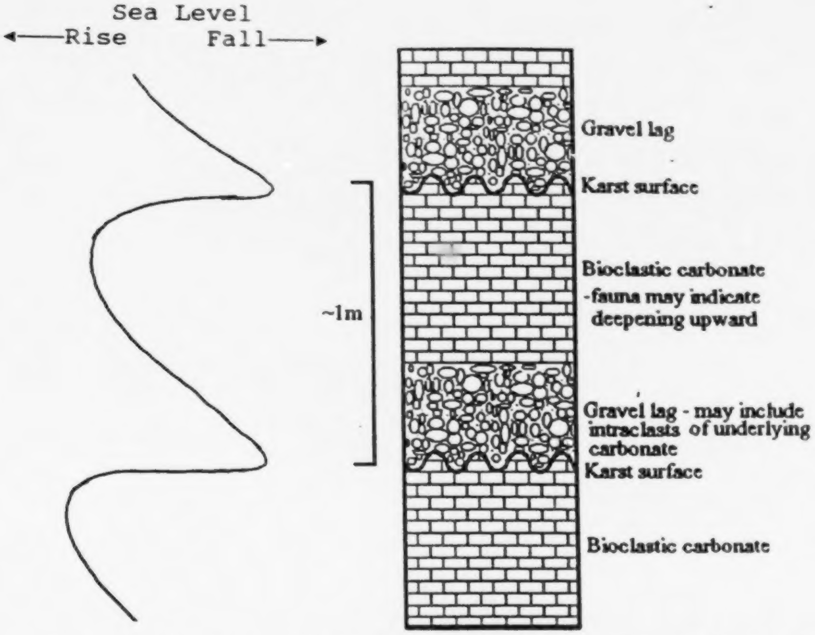

Sea Level
Rise
Fall
~1m
Gravel lag
Karst surface
Bioclastic carbonate
-fauna may indicate deepening upward
Gravel lag - may include intraclasts of underlying carbonate
Karst surface
Bioclastic carbonate

Figure 54a. A hypothetical sequence generated from the carbonate sediments of the study area, assuming a continuing series of alternating glacial and interglacial conditions. Hypothetical sea level curve on left.

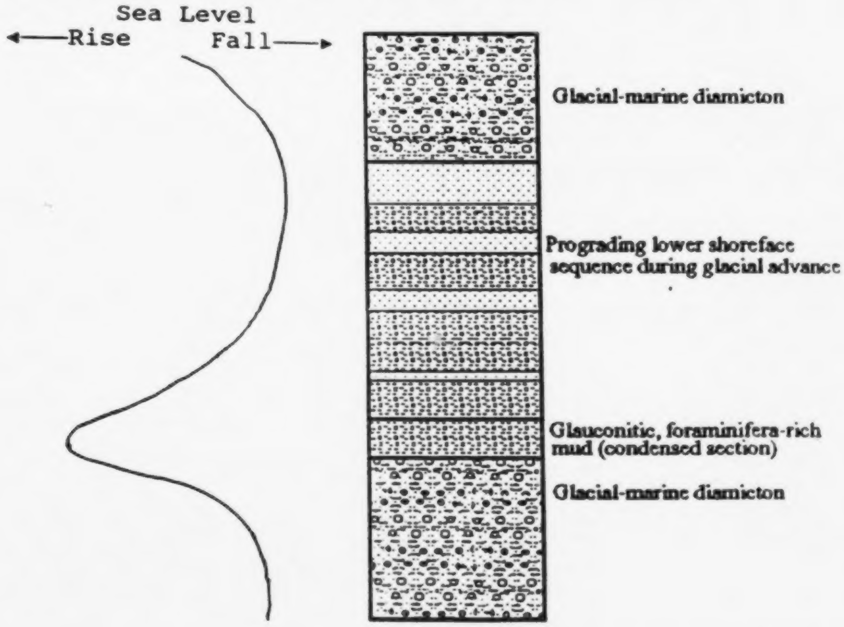

Sea Level
Rise
Fall
Glacial-marine diamicton
Prograding lower shoreface sequence during glacial advance
Glauconitic, foraminifera-rich mud (condensed section)
Glacial-marine diamicton

Figure 54b. A hypothetical section produced on the outer shelf of British Columbia, assuming a continuing series of glacial and interglacial conditions. Hypothetical sea level curve on left.

overlain by a transgressive lag. Not every interglacial deposit would necessarily be represented in the section; some might be too short to generate a sufficiently thick section for preservation, others might be reworked in a transgression prior to cementation.

Deeper water areas on the modern continental shelf of British Columbia are characterized by foraminiferal-rich, glauconitic muds, which are particularly well-developed on the outer shelf of Vancouver Island (Bornhold and Yorath, 1985). With the onset of glaciation, and lowering of sea level, the supply of terrigenous sediment would increase considerably, causing extensive mud deposition (Figure 54b). Isolated topographic highs, brought into shallower water by low sea levels, might be kept free of terrigenous sediment by wave and current action. These areas could become "islands" of carbonate sedimentation in a predominantly muddy depositional environment, which would likely be drowned by glacial-marine sediments with the termination of glaciation.

Effects of Continuing High Sea Levels

The foregoing assumed continuing rapid glacio-eustatic sea level changes. If relative sea level were to remain stable for a long period of time, or to fall slowly, the rivers would gradually prograde outward from the fjords, producing the progradational sequence characteristic of the late highstand systems tract (Posamentier and Vail, 1988; Van Wagoner et al., 1988). The progradational package would differ from that of Van Wagoner et al. (1988) because the oceanographic regime on most of the shelf above 100m is too energetic to allow shale deposition. Thus, the muddy sediments would bypass the inner shelf and be deposited on the outer shelf and within the troughs; the carbonate-producing zone would be buried by prograding shoreface sands (Figure 55a). The carbonates would form a discontinuous blanket over the Tertiary bedrock, cemented under burial conditions and overlain by shoreface sands.

Effects of a Subsequent Sea-level Rise

Because the carbonates are restricted to relatively shallow water, a further rise in sea level would cause the carbonates to be drowned in place. This is regarded as the probable fate of many, perhaps most, temperate carbonate platforms, as sedimentation rates are generally too low to keep up with sea level rises (Simone and Carranante, 1988). With prolonged exposure on the sea floor, the upper surface would become corroded and might eventually become a marine hardground. Authigenic minerals such as glauconite, phosphates and sulphides could form. Unless reactivated by a subsequent drop in sea level, this surface would eventually be buried by pelagic sediments and preserved as a condensed horizon (Figure 55b).

2. "High-Stand" Temperate Carbonates

Definition and Occurrence

The development of temperate carbonates on the British

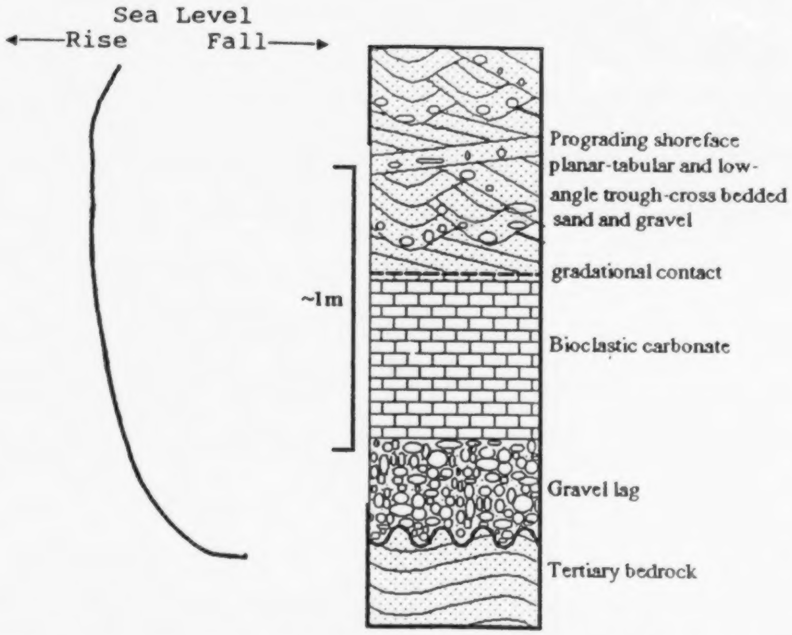

Sea Level
Rise
Fall
~1m
Prograding shoreface planar-tabular and low-angle trough-cross bedded sand and gravel
gradational contact
Bioclastic carbonate
Gravel lag
Tertiary bedrock

Figure 55a. Hypothetical succession produced within the study area, assuming continuing high sea levels or a slow fall in sea level.

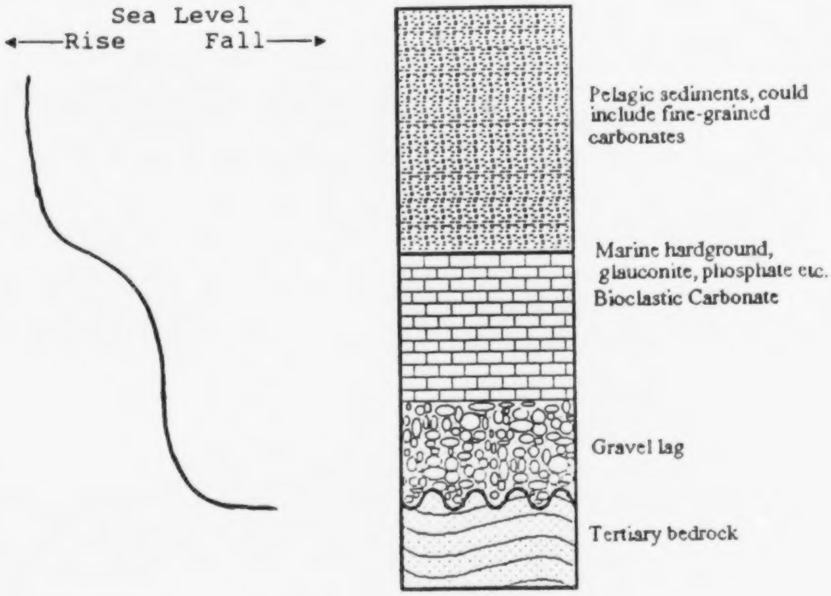

Sea Level
Rise
Fall
Pelagic sediments, could include fine-grained carbonates
Marine hardground, glauconite, phosphate etc.
Bioclastic Carbonate
Gravel lag
Tertiary bedrock

Figure 55b. Hypothetical section produced within the study area, assuming a further transgression "drowns" the deposit.

Columbia continental shelf is closely related to the late Pleistocene-early Holocene transgression. If similar deposits can be recognized in the rock record, this would seem to be a valuable tool in identifying major sea level transgressions.

Although all temperate carbonates accumulate in areas of low terrigenous sediment supply, it cannot be assumed that all temperate carbonates are deposited during high stands in sea level. Some areas are chronically sediment-starved, a condition unrelated to sea level change. These continental shelves, such as the arid southern coast of Australia, typically have few rivers debouching into them, and the surficial sediments of the adjacent continental slope and ocean basin are pelagic in origin (Davies and Gorsline, 1976). Thus, it is clear that these shelves have been sediment-starved for a prolonged period of time. On chronically starved continental shelves, temperate carbonates of considerable thickness can be deposited, such as the Oligo-Miocene Abrakurrie Limestone in southern Australia, whose thickness locally exceeds 100 m (James and Bone, 1991). In contrast, the surficial sediments adjacent to the Atlantic and Pacific coasts of North America and to northwestern Europe were largely derived from the continent during the Pleistocene (Davies and Gorsline, 1976), indicating an abundant supply of sediment to these shelves prior to deglaciation. The widespread occurrence of carbonates on these shelves is a result of the early Holocene transgression and continuing high sea levels. Deposition of these carbonates will cease with the next major sea level fall, so they have a relatively short time span for accumulation.

The rate of biogenic carbonate secretion is generally assumed to be much lower under temperate conditions than for tropical carbonates (Nelson, 1988, Simone and Carranante, 1988), and the rate of accumulation is typically quoted as less than 10 cm/1000 years. Although that would appear to be generally true for the study area, much faster rates have been reported under certain conditions. Farrow et al. (1984) estimated that some areas of the Orkney Islands continental shelf had experienced sedimentation rates exceeding 30 cm/1000 years for most of the Holocene. Belperio et al. (1984) reported carbonates up to 6m thick with sedimentation rates of 100 cm/1000 years from the intertidal zone in southern Australia; and Holocene coralline algal buildups up to 4m high have been described from the the Gulf of Lyons (Bosence, 1985). Workers undertaking studies of invertebrate growth rates in temperate areas have generally found rates similar to those of tropical non-reef environments (Bosence, 1980; Smith, 1988). Smith (1988) suggested that destructive diagenesis, rather than slow growth is principally responsible for the lower rates of accumulation in the temperate zone. Even assuming an accumulation rate of 30 cm/1000 years, which would be unusually high for a temperate shelf, and a 100000 year Milankovitch-forced sea-level cycle, the resulting carbonate deposits formed would not exceed 30m in thickness. Thicknesses of a few meters would likely be much more typical.

Description and Classification of Temperate Carbonates

In view of the variability of terrigenous content, the absence of non-skeletal carbonate grains, and predominance of coarse grain sizes in skeletal carbonates, the traditional descriptive classifications used for carbonate rocks (e.g. Dunham, 1962; Folk, 1962) are inappropriate for many temperate carbonate deposits. As relatively thin bioclastic deposits, they may be more amenable to classification as shell beds.

Kidwell (1991a) provides a detailed framework for field description of temperate carbonates. Table VI is a description of a shell-bed formed from the carbonate sediments of British Columbia, assuming they were lithified and preserved. Kidwell (1991a) also uses a genetic classification for shell concentrations, classifying them as event-concentrations, composite or multiple-event concentrations, hiatal or condensed concentrations and lag concentrations. The deposits of the British Columbia shelf are clearly neither the product of a single event, such as a storm, nor a lag concentration derived from erosion of underlying material. Of the other two possibilities, hiatal concentrations are defined as composite (multiple event) concentrations "that are thin relative to nearby deposits of the same age". Although the carbonates are obviously hiatal in the sense that they represent a period of minimal terrigenous sediment input,

Table VII. Features of B.C. carbonates preserved as shellbeds

Paleontologic features:	
Number of Species:	typically 10-20 molluscan species, plus other phyla
Relative Abundance:	one dominant species, many with one or few individuals
Taxonomic Composition:	molluscs, bryozoans, barnacles
Ecological Spectrum:	benthos, mixed infaunal and epifaunal, hard bottom, suspension feeders dominant
Age Spectrum:	mixed adults and juveniles
Original Mineralogy:	mixed
Preserved Mineralogy:	low Mg calcite
Taphonomic features:	
Articulation:	disarticulated and dissociated
Size sorting:	poor
Modal size and range:	mode -1 phi, range up to -8 phi
Shape sorting:	unsorted
Fragmentation:	most broken
Abrasion:	unabraded to highly abraded
Rounding:	angular to rounded
Biol. modification:	extensive bioerosion and encrustation on many shells
Orientation:	disturbed (not in life position)
In plan view :	?
In cross-section:	high variance, some horizons concordant, convex up
Sedimentologic features:	
Matrix:	medium to coarse sand
Hydraulic equivalence:	same as fine shell material?
Relative abundance:	up to 98%
Packing:	densely packed
Associated structures:	generally uniform within massive beds, sometimes concentrated at base of graded beds
Stratigraphic features:	
Thickness:	up to 2 metres?
Lateral extent:	up to about 100 km in Hecate Strait, but discontinuous
Relative Scale:	within facies
Geometry:	bed or "pavement"
Internal complexity:	complex microstratigraphy
Physical contacts:	base sharp, laterally gradational, top ?
Position in sequence:	within a transgressive and high stand systems tract
Associated with:	marine flooding surface and Type I unconformity

using this definition, their status is unclear. They are certainly thin relative to the sediments accumulating in the fjords, and in some troughs on the shelf (Luternauer and Murray, 1983); however, they are probably as thick or thicker than the foraminiferal-rich, glauconitic muds accumulating on the outer shelf and the terrigenous sands on much of Dogfish Bank.

Kidwell et al. (1991b) differentiated between areas of low net terrigenous sedimentation as a result of starvation, total passing or dynamic bypassing. Starvation is a condition where there is no terrigenous input to the shelf, while in total passing there is a terrigenous input, but it is too fine to be deposited. Dynamic bypassing is a condition where terrigenous sediment is only temporarily deposited, then removed by the next sedimentation event. For example, a setting in which fine-grained terrigenous sediment is deposited, but swept away by successive storm events, leaving amalgamated shelly storm deposits, would be described as experiencing dynamic bypassing. The continental shelf of British Columbia is generally under starvation, although near the Skeena River outflow and the fjords near Sea Otter Shoals there is some fine-grained sediment which escapes the coastal zone. Shallow water areas near these terrigenous outflows could experience total passing, rather than starvation.

Recognition of Shell Beds as Condensed Horizons

A number of characteristics from Table VI could be used to recognize this hypothetical deposit as a hiatal or composite concentration on a shelf experiencing total passing or starvation. Clearly, the deposit would not be mistaken for the result of a single hydrodynamic event; it lacks the grading and sorting generally associated with such deposits (e.g. Kreisa and Bombach, 1982; Furzich and Oschmann, 1986). In fact, according to the Wilson (1988) model, which may be supported by the core evidence, the proportion of carbonate and grain size may increase over time, which could produce a coarsening upward sequence. The process by which the dead organisms provide a substrate for colonization, enhancing the rate of biogenic carbonate production, was termed taphonomic feedback by Kidwell (1986).

Because the deposit overlies a major unconformity and a marine flooding surface, it might, however, resemble a lag deposit. Lags are also commonly thin sheets overlying an erosional surface, however, shells within a lag are typically in very poor condition (Kidwell, 1991a). While many of the shells from the study area are in poor condition, others are quite fresh, which is not characteristic of shells exhumed and reworked from older deposits. The faunal assemblage within the deposit is consistent with a shell gravel substrate; a lag deposit would have a faunal assemblage reflecting the environment(s) of deposition of the underlying sediments. Furthermore, in most areas the shell-beds probably do not overlie the Tertiary bedrock directly, but overlie a terrigenous gravel lag derived from erosion of glacial deposits. The thickness of the shellbeds, while highly variable, is at least 1.2m locally, which would be unusually thick for an erosional lag (Kidwell, 1991a). Finally, as sea level continued to rise after the establishment of the carbonate-dominated regime, it is possible that the base of the shell bed would contain a shallower water fauna than the top, although this could not be confirmed by the cores from Cook Bank. This last signal may not be recognizable in all "high-stand" temperate carbonates, as bioturbation and reworking by wave and currents can homogenize or "time-average" the faunal assemblage (Kidwell and Bosence, 1991). Thus, detailed description of the basal facies above the unconformity and the faunal assemblage within the bed should differentiate this kind of deposit from a lag deposit or event bed.

Within the Kidwell (1991a) classification framework, the distinction between hiatal and composite sections is not based on the characteristics of the individual bed, but on its thickness relative to coeval strata. As has been stated, the strict use of the Kidwell (1991a) definition of hiatal leads to a problem, as whether it is hiatal or composite would depend on the thickness of the coeval strata to which it is compared.

It should also be possible to differentiate the sediments of British Columbia, which result from total passing or starvation, from those resulting from dynamic bypassing. Kidwell (1991b) contrasted deposits formed under dynamic bypassing conditions with those formed under conditions of starvation. The hypothetical shell bed described in Table VI differs from that which would be produced under dynamic bypassing. It contains a fauna predominantly of organisms that live on rock and gravel, intensely encrusted and bioeroded shells, and no lenses of fine sediment. Thus, there is evidence of a coarse-grained substrate at the seafloor, long-term exposure of shells, and no evidence for burial by fine-grained sediment. Kidwell (1991a) regards the highly variable degree of shell degradation to be an excellent indicator of hiatal shell concentrations. Although there is no specific climatic interpretation in the shell concentration classification, the temperate carbonates of British Columbia display all the characteristics regarded by Kidwell (1991a, 1991b) as typical of hiatal concentrations.

Although marine transgression is, perhaps, the most commonly invoked method of starving the shelf of sediment, there are other circumstances by which an area can be starved of terrigenous sediment. However, these carbonates would be preserved as a regionally extensive, although discontinuous, blanket of bioclastic material grading seaward into glauconitic sands and muds. The lateral extent of the deposit and the association with glauconite, which is regarded as indicative of very slow deposition (Odin and Matter, 1981), would reveal that the low terrigenous sediment supply was a regional condition, not a reflection of local sediment bypassing. Furthermore, the deposit would overlie a regionally correlatable erosion surface, marked by a lag deposit. The underlying unit might be terrestrial or show signs of subaerial weathering in more shoreward areas, and be marked by shallow water indicators in the basinward area. The faunal assemblages within the carbonate unit might show evidence of deepening upward, or an increase in fine sediment or glauconite, indicative of continued transgression.

Sequence Stratigraphic Significance

It should be possible to recognize ancient deposits which formed under conditions similar to those prevailing in the study area through careful examination of the faunal composition, taphonomic features and associated sedimentary facies of the deposit. These deposits could be viewed as shallow water condensed sections, a coarse-grained, bioclastic analog to the glauconitic and phosphatic muds which compose the classical condensed section (Von Wagoner et al., 1988; Loutit et al., 1988). As temperate carbonates are widespread on modern continental shelves, it seems reasonable to include them within the model for transgressive and high-stand systems tracts.

In high latitudes (>45°) shallow-water carbonates appear to be restricted to continental shelves experiencing high wave or tidal energy, such as those of British Columbia, the

British Isles and New Zealand. Many sequence stratigraphic models implicitly assume that the shelf beyond the shoreface is quiet, and show condensed sections downlapped by fine-grained sediments (e.g. Van Wagoner et al., 1988; Figure 56a). In contrast, progradational parasequences in areas such as Hecate Strait, Queen Charlotte Sound, and the seas surrounding the British Isles would be characterized by temperate carbonates and palimpsest sands and gravels downlapped by coarse-grained shoreline deposits. Figure 56b could be regarded as a model parasequence for a high energy continental shelf; only on the outer shelf would the traditional model apply.

Temperate carbonates may be more commonly associated with Type I sequences, in which subaerial erosion occurs, because subaerial erosion can produce rocky or gravelly substrates which favour carbonate production. While the low rate of dilution by terrigenous sediments is generally stressed as the dominant factor influencing carbonate deposition (e.g. Chave, 1967; Nelson, 1988), conditions favourable to biogenic carbonate production are also required. Turbulent water conditions and high nutrient availability, in combination with a stable substrate, appear to be the most favourable conditions for carbonate development. The presence and distribution of bioclastic sediments within a high-stand systems tract may, therefore, provide clues to the environmental conditions on the shelf during deposition.

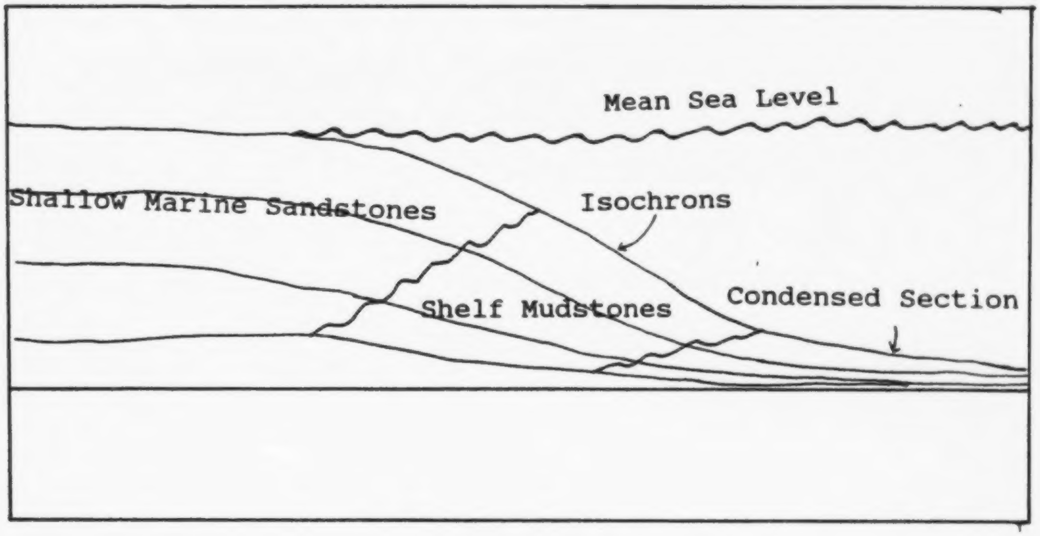

Mean Sea Level
Shallow Marine Sandstones
Isochrons
Shelf Mudstones
Condensed Section

Figure 56a. A classical progradational parasequence. Modified from Van Wagoner et al. (1988).

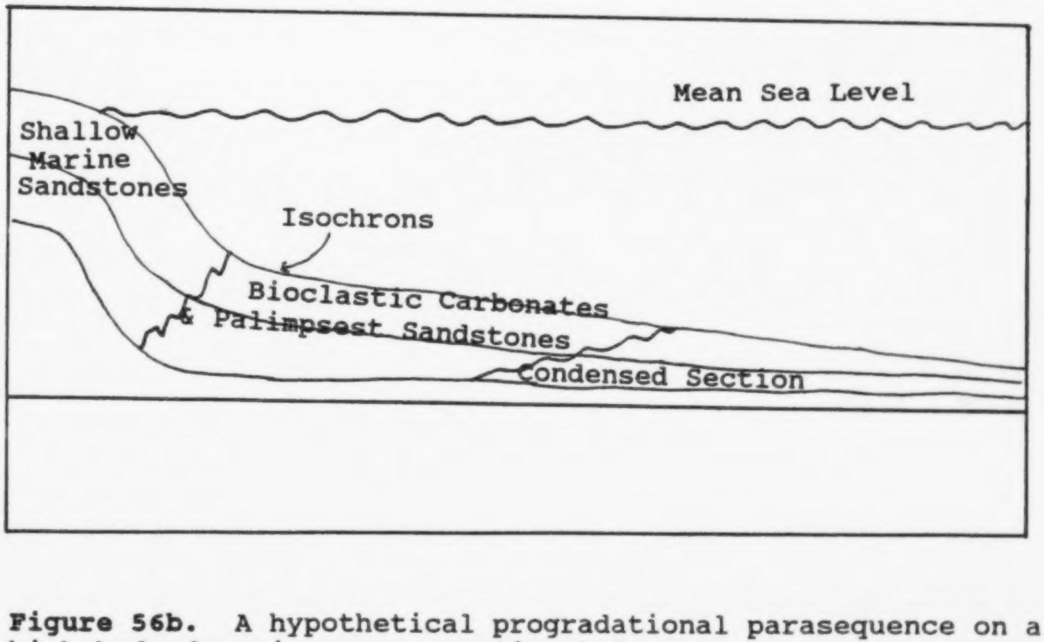

Mean Sea Level
Shallow Marine Sandstones
Isochrons
Bioclastic Carbonates & Palimpsest Sandstones
Condensed Section

Figure 56b. A hypothetical progradational parasequence on a high hydrodynamic energy continental shelf.

3. Ancient Analogs for Temperate Carbonates

In view of their widespread geographical extent in modern oceans, there are surprisingly few documented occurrences of ancient temperate carbonates (Nelson, 1988). One possible explanation for this is lack of recognition, which has generally been attributed to the overwhelming dominance of tropical facies models. The occurrence of many modern temperate carbonates is a result of the Holocene transgression and high stand in sea level; any carbonates preserved from these shelves will be preserved as relatively thin units in a dominantly clastic succession. Therefore, unless a large number of cycles occur, they are often not thought of as "carbonates", temperate or tropical, but as shell beds or "coquinas".

Kidwell (1991a) listed 38 hiatal shell concentrations, a number of which were clearly deposited under temperate conditions, but have not been identified as "temperate carbonates" *per se*. Thus, there may be a large number of analogous sediments from the past, to which the name "temperate carbonates" has never been applied.

Several ancient temperate carbonate sequences have been identified which show numerous alternations between clastic and carbonate deposition. The best documented of these are from Australia (Rao, 1981) and New Zealand (Beu and Edwards, 1984; Kamp and Nelson, 1988), where the presence of modern temperate carbonates may inspire greater interest in ancient examples. Curiously, many of these carbonates gradationally overlie muddy sediments deposited in deeper water, and are interpreted as having been deposited during low stands of sea level. Kamp and Nelson (1988) demonstrated that many of these carbonate deposits are located on paleo-highs created by faulting, and were sites of carbonate deposition because of sediment bypassing.

One exception to these "low-stand carbonates" are the carbonate-clastic cycles in the Pleistocene Castlecliff section in New Zealand (Fleming, 1953; Beu and Edwards, 1984). These resemble the Holocene carbonates of British Columbia in their association with transgressive surfaces, evidence of subaerial erosion, and variable quality of preservation of the fauna. These transgressive surfaces were shown to be correlative with oxygen isotope stages and, therefore, regarded by Beu and Edwards (1984) as glacio-eustatically generated. Although Kamp and Nelson (1987) referred to these deposits as "transgressive lags", the interpretation of Fleming (1953) of dynamic bypassing with minor incorporation of underlying material is more consistent with the thickness (1-2 m or more) of the deposits. They do, however, differ from the carbonates of the study area in several important respects. They contain a number of shallow water, mud-dwelling species, suggesting that the substrates in which these species lived was winnowed away (Fleming, 1953). In several cases, they are overlain by marine mudstones, indicating that continuing transgression drowned the incipient carbonate platform. Finally, the sedimentation rates for the section are remarkably high (40-130 cm/1000 (Beu and Edwards (1984)), although this may reflect rapid deposition of the terrigenous intervals.

Although not explictly described as temperate carbonates, the Miocene shell beds of Maryland described by Kidwell (1991b), resemble the deposits of the study area in many respects. The 0.5-2 m thick shell beds are composed of poorly sorted shell material in a winnowed sand matrix, overlying erosional disconformities (Figure 57). The beds can be correlated for hundreds to thousands of square kilometers, and are thickest, most carbonate-rich and closest together over paleohighs; in some cases they are amalgamated into a single thick shell bed. They display a variety of degrees of preservation, many shells are intensely bioeroded, and the shell-rich layers are composed predominantly of species adapted to living in shell gravels. The shell beds are interpreted as accumulating in a nearshore area above storm wave base, in response to low terrigenous input during high sea level stands, and are described as condensed sections. In short, these deposits do not appear to differ substantially from those of British Columbia, except in the specific faunal assemblages. The climate of the Miocene in Maryland, while certainly warmer than that of British Columbia, was mild- to warm-temperate and comparable to that of North and South

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Figure 57. A shell bed from the Miocene of Maryland; a possible ancient analog for the British Columbia carbonates. The arrow indicates the disconformity at the base of the unit. From Kidwell (1989).

Carolina today (McCartan et al., 1990). Thus, this is a true transgressive to high-stand temperate carbonate, not a tropical deposit.

Several possible analogs exist on the Pacific Coast of North America, but are not described in as much detail as the Miocene of Maryland. Wright (1972) reported a 0.3-1m thick bed of cool-temperate Pleistocene mollusks and foraminifera overlying an unconformity in California. The fauna was interpreted as shallow water, rocky to level bottom; a similar faunal assemblage to that in Hecate Strait. A similarly mixed hard and soft-bottom fauna was described from a Pleistocene marine terrace in Oregon (Addicott, 1974). The shell bed is 0.6-1m thick and overlies an unconformity. Thus, similar deposits from the Pleistocene have been preserved at other locales along the Pacific Coast.

Despite the absence of many deposits described as "temperate carbonates", there are clearly a number of examples of ancient sediments similar to those currently accumulating on the British Columbia continental shelf. These deposits appear to be similar not only in composition, but in their relationship to relative sea level, which suggests that these sediments may provide a valid model for interpreting past sediments.

Nelson (1988) noted that most examples of carbonates with temperate faunal assemblages were deposited during glacial episodes, such as the Permo-Carboniferous and late Tertiary, and suggested that cool water shelf limestones would be best developed when a strong latitudinal temperature gradient existed. In view of the possible limitation of the coralgal assemblage by light (Ziegler et al., 1984), an alternative explanation may be that temperate carbonates are best developed during glacial episodes because short-term, high-amplitude sea level fluctuations are especially favourable to their development.

VI. CONCLUSIONS

1) Sediments composed predominantly of calcium carbonate are accumulating over an area of approximately 4000 km2 in Hecate Strait. These sediments are similar in age, composition, and distribution to those of Cook Bank, first described by Nelson and Bornhold (1983). They are restricted to relatively shallow water, less than 50m in Hecate Strait, and about 100m on Cook Bank, and are closely associated with gravel substrates. The faunas in these sediments are predominantly suspension feeders, particularly bivalves, barnacles and bryozoans, comprising a typical "foramol" assemblage. The sediments contain a mixture of infaunal bivalves, principally those tolerant of coarse substrates, and a variety of epifaunal organisms. The deposit is thin (typically 0.5-1 m thick), interspersed with bedrock outcrops, and the chief constituent of large oscillatory ripples produced by storm waves.

2) The carbonate sediments are accumulating in response to very low terrigenous sediment input to the continental shelf, combined with several factors which favour suspension-feeding biogenic carbonate producers. The principal factors appear to be high wave and tidal energy, and rock and gravel substrates which provide a relatively stable environment in turbulent conditions. Periodic upwelling of cold, nutrient-rich waters may also enhance productivity.

3) Little evidence of long-distance transport of shelly

faunas exists; most of the organisms could be expected to be living in the immediate vicinity of the deposit. Fragmentation of the material occurs rapidly, due to physical reworking, intense bioerosion and dissolution. Fine-grained carbonate appears to be rare, possibly as a result of rapid destruction by abrasion and dissolution.

4) Carbonate accumulation on the shelf appears to have been occurring for at least 7500 years, although dates on surficial samples are less than 1500 years. Cores from Cook Bank suggest that the carbonate-rich areas may have expanded during the Holocene, possibly due to taphonomic feedback as predicted by Kidwell (1986) and Wilson (1988). Carbonate sedimentation rates appear to be on the order of 5-10 cm/1000 years, which is fairly typical for a temperate carbonate deposit.

5) Conditions favourable to carbonate deposition are largely a result of the glacial and post-glacial history of the region. Low sea level stands at the close of the Pleistocene exposed much of the shelf to subaerial erosion, exposing bedrock and winnowing glacial tills to a gravel lag suitable for colonization by epifaunal organisms. The ensuing transgression trapped nearly all sediment in the coastal areas, preventing the dilution of the carbonate deposits by terrigenous material.

6) Although no evidence of pre-existing Pleistocene temperate carbonates was observed, several mechanisms could

preserve the unit in the stratigraphic record. If buried by shoreline or terrestrial sediments, the deposit could survive subaerial erosion and be cemented by meteoric diagenesis during a low-stand of sea-level. Alternatively it could be buried by prograding shoreface sediments or "drowned" by a further transgression. Any preservation would involve the recrystallization of much of the aragonitic fraction of the sediment; the resulting sediments might be relatively enriched in bivalves and barnacles.

7) If preserved, a number of characteristics would allow the carbonates of British Columbia to be recognized as a result of low terrigenous input induced by a major transgression. They would comprise a thin, discontinuous blanket of bioclastic carbonate overlying a subaerial erosion surface and associated erosional lag (Figure 54a). Some, but not all, of the shells would be highly abraded and bioeroded, indicative of prolonged exposure on the sea floor. The faunal assemblage, made up of organisms tolerant of rock and shell-gravel habitats, and the association with glauconitic sands and muds in the basin, would indicate a shelf-wide event which limited terrigenous sediment input. Thus, the deposit could be regarded as a coarse-grained, shallow water equivalent of a condensed section. Such deposits should be a common feature of the transgressive and high-stand systems tracts, particularly on shelves where wave and/or tidal energy is high.

8) The best ancient analog identified is the Miocene shell-beds of Maryland described by Kidwell (1991b). Pleistocene shell-beds from marine terraces in California and Oregon, and cyclic shell-beds from the Pleistocene of New Zealand also show similar characteristics. Many shell-beds in clastic sequences may represent temperate carbonates deposited subsequent to transgressive events. This may partially account for the paucity of documented temperate carbonate deposits in the geological literature.

9) Because temperate carbonates contain abundant fossil material, and are sensitive to sea level changes, they have great potential for use in paleoecological reconstructions. Detailed analysis of shell-rich deposits in clastic sequences may provide a information on hydrodynamic conditions and biological productivity that could otherwise be overlooked.

10) Temperate carbonates which can be recognized as condensed horizons can play important roles in sequence stratigraphy. They may allow recognition of marine flooding surfaces and sequence boundaries, and of a hiatus in sedimentation. If they are of sufficient lateral extent, they may also serve as stratigraphic datums.

VII. BIBLIOGRAPHY

Abbott, R.T. 1974. American Seashells. Van Nostram Reinhold Co., New York, NY. 663 p.

Addicott, W.O. 1964. A late Pleistocene invertebrate fauna from southwestern Oregon. Journal of Paleontology, v.38, p. 688-695.

Aharon, P. 1984. Implications of the coral record from New Guinea concerning the astronomical theory of ice ages. In Milankovitch and Climate edited by A.Berger, J. Imbrie, J. Hays, G. Kukla and B. Saltzman. NATO ASI Series C: Mathematical and Physical Sciences, v. 126. p. 379-389.

Alavi, S.N, Ediger, V., and Ergin, M. 1989. Recent sedimentation on the shelf and upper slope in the Bay of Anamur, Southern coast of Turkey. Marine Geology, v. 89, p. 29-56.

Alexandersson, E.T. 1969. Recent littoral and sublittoral high-Mg calcite lithification in the Mediterranean. Sedimentology, v. 12, p. 47-61.

Alexandersson, E.T. 1974. Carbonate cementation in coralline algal nodules in the Skaggerak, North Sea; biochemical precipitation in undersaturated waters. Journal of Sedimentary Petrology, v. 44, p. 7-26.

Alexanderrson, E.T. 1975. Etch patterns on calcareous sediment grains: petrographic evidence of marine dissolution of carbonate minerals. Science, v. 189, p. 47-48.

Alexandersson, E.T. 1979. Marine maceration of skeletal carbonates in the Skaggerak, North Sea. Sedimentology, v. 26, p. 845- 852.

Ashley, G.M. 1990. Classification of large-scale subaqueous bedforms: a new look at an old problem. Journal of Sedimentary Petrology, v.60, p. 160-172.

Barber, F.G. 1957. Observations of currents north of Triangle Island, British Columbia. Progress Reports of the Pacific Coast Stations, v. 108, p. 15-18.

Barrie, J.V. 1988. Surficial geology of Hecate Strait, British Columbia continental shelf. Geological Survey of Canada, Open File Report 1682.

Barrie, J.V. and Bornhold, B.D. 1989. Surficial geology of Hecate Strait, British Columbia continental shelf. Canadian Journal of Earth Sciences, v. 26, p. 1241-1254.

Barrie, J.V., Emory-Moore, M., Luternauer, J.L. and Bornhold, B.D. 1988. Origin of modern heavy mineral deposits, Northern British Columbia continental shelf. Marine Geology, v. 84, p. 43-51.

Belperio, A.P., Gostin, V.A., and Polach, H.A. 1984. The stratigraphy of coastal carbonate banks and Holocene sea levels of northern Spencer Gulf, South Australia. Marine Geology, v. 61, p. 297-313.

Bernard, F.R. 1970. A distributional checklist of the marine molluscs of British Columbia: based on faunistic surveys since 1950. Syesis, v. 3, p. 75-94.

Beu, A.G. and Edwards, A.R. 1984. Pleistocene and late Pliocene glacio-eustatic cycles. Palaeogeography, Palaeoclimatology, Palaeoecology, v. 46, p. 119-142.

Blom, W. and Alsop, D. 1988. Carbonate mud sedimentation on a temperate shelf; Bass Basin, southeast Australia. Sedimentary Geology, v. 60, p. 259-280.

Boillot, G. 1965. Organogenic gradients in the study of neritic deposits of biological origin: the example of the western English Channel. Marine Geology, v. 3, p. 359- 367.

Bornhold, B.D. and Barrie, J.V. 1991. Surficial sediments of the western Canadian continental shelf. Continental Shelf Research, v. 11, p.685-700.

Bornhold, B.D. and Giresse, P. 1985. Glauconitic sediments on the continental shelf off Vancouver Island, British Columbia, Canada. Journal of Sedimentary Petrology, v. 55, p. 644-653.

Bornhold, B.D. and Yorath, C.J. 1984. Surficial geology of the continental shelf, northwestern Vancouver Island. Marine Geology, v. 57, p. 89-112.

Bosence, D.W.J. 1980. Sedimentary facies, production rates and facies models for Recent coralline algal gravels, County Galway, Ireland. Geological Journal, v. 15, p. 91-111.

Bosence, D.W.J. 1985. The coralligene of the Mediterranean--a recent analog for Tertiary coralline algal limestones. In Paleoalgology: Contemporary Research and Applications. Edited by D.F. Toomey and M.H. Nitecki, p. 216-225.

Burd, B.J. and Brinkhurst, R.O. 1987. Macrobenthic infauna from Hecate Strait, British Columbia. Canadian Technical Report of Hydrography and Ocean Sciences, no. 88. 127p.

Canadian Hydrographic Service. 1976. Sailing directions, British Columbia Coast, v. II: north portion. Department of Fisheries and Oceans, Ottawa. 306 pp.

Carannante, G., Esteban, M., Milliman, J.D. and Simone, L. 1988. Carbonate lithofacies as paleolatitude indicators; problems and limitations. Sedimentary Geology, v. 60, p. 333-346.

Carannante, G., Simone, L, and Barbera, C. 1981. Calcari a Briozoi e Litoamni of Southern Appennines: Miocene analogues of recent Mediterranean rhodolitic sediments. International Association of Sedimentology, 2nd European Meeting, Bologna, p. 17-20

Carrigy, M.A. 1956. Organic sedimentation in Warnbro Sound. Journal of Sedimentology, v. 26, p. 228-239.

Caulet, J. 1972. Recent biogenic calcareous sedimentation on the Algerian continental shelf. **In** D.J. Stanley (Editor), The Mediterranean Sea. Dowden, Hutchinson and Ross, Stroudsburg, Pa., p. 261-278.

Chave, K.E. 1967. Recent carbonate sediments--an unconventional view. Journal of Geological Education, v. 15, p. 200-204.

Clague, J.J., Mathewes, R.W. and Warner, B.G. 1982. Late quaternary geology of eastern Graham Island, Queen Charlotte Islands, British Columbia. Canadian Journal of Earth Sciences, v. 19, p. 1786-1795.

Clifton, H.E., Hunter, R.E. and Phillips, R.L., 1971. Depositional structures and processes in the non-barred, high energy nearshore. Journal of Sedimentary Petrology, v. 41, p. 651-670.

Collins, L.B. 1988. Sediments and histroy of the Rottnest Shelf, southwest Australia: a swell-dominated, non-tropical carbonate margin. Sedimentary Geology, v. 60, p. 15-49.

Conway, K.E. 1987. Data report on the Surficial Geology of Hecate Strait. Geological Survey of Canada, Open File Report 1349.

Crawford, W.R., Huggett, W.S. and Woodward, M.J. 1988. Water transport through Hecate Strait, British Columbia. Atmosphere-Ocean, v. 26, p. 301-320.

Cuffey, R.J., Stadum, C.J. and Cooper, J.D. 1981. Mid-Miocene bryozoan coquinas on the Aliso Viejo Ranch, Orange County, southern California. In G.P. Larwood and C. Nielsen (Editors), Recent and Fossil Bryozoa. Olsen and Olsen, Durham. p. 65-72.

Davies, T.A. and Gorsline, D.J. 1976. Oceanic sediments and sedimentary processes. In Chemical Oceanography, edited by J.P. Riley and R. Chester.

Department of Fisheries and Oceans. 1991. Sailing Directions: British Columbia Coast (North Portion). Department of Fisheries and Oceans, Ottawa. 306 p.

Dorjes, J. and Hertweck, G. 1970. Recent biocoenoses and ichnocoenoses in shallow water marine environments. In The Study of Trace Fossils, Edited by Frey, R.W. Springer- Verlag, New York. p. 459-491.

Dunham, R.J. 1962. Classification of carbonate rocks according to depositional texture In Classification of carbonate rocks edited by W.E. Ham) p. 108-121. AAPG Memoir 1

Elliott, T. 1986. Siliciclastic shorelines. In Reading, H.G. (Editor), Sedimentary Environments and Facies. Blackwell Scientific Publications, Oxford. p. 155-188.

Emery, K.O. 1968. Relict sediments on the continental shelves of the world. AAPG Bulletin, v. 52, p. 445-464.

Fairbridge, R.W. 1967. Carbonate rocks and paleoclimatology in the biogeochemical history of the planet. In: G.V. Chilingar, H.J. Bissell and R.W. Fairbridge (Editors), Developments in Sedimentology 9A, Carbonate Rocks: Origin, Occurrence and Classification., p. 399-432.

Farrow, G.E. 1974. On the ecology and sedimentation of the Cardium shell sands of Traigh Mhor, Island of Barra, Outer Hebrides. Transactions of the Royal Society of Edinburgh, v. 69, p. 203-227.

Farrow, G.E., Allen, N.H., and Akpan, E.B. 1984. Bioclastic sedimentation on a high latitude, tide-dominated shelf: northeast Orkney Islands, Scotland. Journal of Sedimentary Petrology, v. 54, p. 373-393.

Fleming, 1953. The geology of Wanganui subdivision, Waverly and Wanganui Sheet districts. New Zealnad Geological Survey Bulletin, v. 52. 362 pp.

Folk, R.L. 1962. Spectral subdivision of limestone types. In Classification of Carbonate Rocks edited by W.E. Ham. AAPG Memoir 1. p. 62-84.

Furzich, F.T. and Oschmann, W. 1986. Storm shell beds of _Nanogyra_ _virgula_ in the upper Jurassic of France. Neues Jahrbuch fur Geologie und Paleontologie Abhandlungen. v. 172, p. 141-161.

Gostin, V.A., Belperio, A.P. and Cann, J.H. 1988. The Holocene non-tropical coastal and shelf carbonate province of southern Australia. Sedimentary Geology, v. 60, p. 51-70.

Halderson, S., Jorgensen, P., Rappol, M., and Rezebos, P.A. 1989. Composition and source of the clay-size fraction of Saalian till in The Netherlands. Boreas, v. 18, p. 89-97.

Holland, S.S. 1964. Landforms of British Columbia - a physiographic outline. Bulletin of the British Columbia Department of Mines and Petroleum Resources, No. 48. 138 pp.

Hommeril, P. 1971. Dynamique du transport des sediments calcaires dans la partie nord du golfe Normand-Breton. Bulletin de Societe Geologique du France, v. 7. p. 31-41.

Hoskin, C.M. and Nelson, Jr., R.V. 1969. Modern marine carbonate sediments, Alexander Archipelago, Alaska. Journal of Sedimentary Petrology, v. 39, p. 581-590.

Hovland, M., Talbot, M.R., Qvale, H., Olaussen, S., and Aasberg, L. 1987. Methane-related carbonate cements in pockmarks of the North Sea. Journal of Sedimentary Petrology, v. 57, p. 881-892.

James, N.P. 1984. Reefs. _In_ R.G. Walker (Editor), Facies Models. Ainsworth Press Ltd., Kitchener, p. 229-244.

James, N.P. 1988. Diagenesis of temperate water carbonates: a better model for the meteoric/shallow burial alteration of Phanerozoic shallow water calcite sediments. Central Canada Geological Conference '88, Abstracts, p. 54. University of Western Ontario, London, Ontario.

James, N.P. and Bone, Y. 1991. Origin of a cool water Oligomiocene deep-shelf limestone, Eucla Platform, Southern Australia. Sedimentology, v. 38, p. 323-341.

Jorgensen, N.O. 1976. Recent high magnesian calcite/aragonite cementation of beach and submarine sediments from Denmark. Journal of Sedimentary Petrology, v. 57, p. 881-892.

Jorgensen, N.O. 1992. Methane-derived carbonate cementation of marine sediments from the Kattegat, Denmark: geochemical and geological evidence. Marine Geology, v. 103, p. 1-13.

Kamp, P.J.J., Hansen, F.J., Nelson, C.S. and Boyle, S.F. 1988. Barnacle-dominated limestone with giant cross-beds in a non-tropical, tide-swept, Pliocene forearc seaway, Hawke's Bay, New Zealand. Sedimentary Geology, v. 60, p. 173-195.

Kamp, P.J.J., and Nelson, C.S. 1987. Tectonic and sea level controls on non-Tropical Neogene limestones in New Zealand. Geology, v. 15, p. 610-613.

Kamp, P.J.J., and Nelson, C.S. 1988. Nature and occurrence of Neogene active margin limestones in New Zealand. New Zealand Journal of Geology and Geophysics, v. 31, p. 1-20.

Keen, A.M. 1963. Marine Molluscan Genera of Western North America. Stanford University Press, Stanford, CA. 126p.

Kenyon, N.H. 1970. Sand ribbons of European tidal seas. Marine Geology, v. 9, p. 25-39.

Kerr, R.S. 1980. The dissolution kinetics of biogenic carbonates in sea water. Geochimica et Cosmochimica Acta, v. 44, p. 241-252.

Kidwell, S.M. 1991a. The stratigraphy of shell concentrations. In Taphonomy--releasing the data locked in the fossil record, Edited by P.A. Allison and D.E.G. Briggs Plenum Press, New York. p. 211-290.

Kidwell, S.M. 1991b. Stratigraphic condensation of marine-transgressive records: origin of major shell deposits in the Miocene of Maryland. Journal of Geology, v. 97, p. 1-24.

Kidwell, S.M. and Bosence, D.W.J. 1991. Taphonomy and time-averaging of marine shelly faunas. In Taphonomy: Releasing the Data Locked in the Fossil Record. Topics in Geobiology, v. 9. Edited by P.A. Allison and D.E.G. Briggs, Plenum Press, New York. p. 115-209.

Kidwell, S.M., Fursich, F.T. and Aigner, T. 1986. Conceptual framework for the analysis and classification of fossil concentrations. Palaios, v. 1, p. 228-238.

Kreisa, R.O. and Bombach, R.K. 1982. The role of storm processes in generating shell beds in the Paleozoic shelf environments. In Cyclic and Event Stratification edited by Einsele, G. and Seilacher, A., p.200-207.

Kulczynski, S. 1928. Die Pflanzenassoziationen der Pieninen. Bull. int. Acad. polonaise Sci. et Lettres. Classe Sci. math. et nat., Serie B. Suppl. II: 57-203.

Kozloff, E.N. 1987. Marine Invertebrates of the Pacific Northwest. University of Washington Press. 572 pp.

Lee & Adkins, Ltd. 1978. Faunal identifications of samples from the Scott Islands Shelf. Unpublished report. 54 pp.

Lee, J.C. & Associates. 1982. Faunal identifications of samples from Hecate Strait. Unpublished report. 50 pp.

Lees, A. 1975. Possible influence of salinity and temperature on modern shelf carbonate sedimentation. Marine Geology, v. 19, p. 159-198.

Lees, A. and Buller, A.T. 1972. Modern temperate-water and warm-water shelf carbonates contrasted. Marine Geology, v. 13, M67-M73

Lees, A., Buller, A.T. and Scott, J. 1969. Marine carbonate sedimentation processes, Connemara, Ireland. University of Reading, Geological Department Report, v. 2, 64 pp.

Legendre, L. and Legendre, P. 1983. Numerical ecology. Developments in Environmental Modelling, v. 3. Elsevier, Amsterdam. 419 pp.

Leonard, J.E. and Cameron, B.W. 1981. Origin of a high latitude carbonate beach: Mt. Desert Island, Maine. Northeastern Geology, v. 3, p. 178-183.

Leonard, J.E., Cameron, B.W., Pilkey, O.H. and Friedman, G.M. 1981. Evaluation of cold-water carbonates as a possible paleoclimatic indicator. Sedimentary Geology, v. 28, p. 1-28.

Levinton, J.S. 1982. Marine Ecology. Prentice-Hall, Inc., Englewood Cliffs, N.J. 526 p.

Loutit, T.S., Hardenbol, J., Vail, P.R. and Baum, G.R. Condensed sections: the key to age dating and correlation of continental margin sequences. In Wilgus, C.K., Hastings, B.S., Kendall, C.G.St.C., Posamentier, H.W., Ross, C.A., and Van Wagoner, J.C. (Editors), Sea Level Changes: an Integrated Approach. SEPM Special Publication 42.

Luternauer, J.L. 1986. Character and setting of sand and gravel bedforms on the open continental shelf off western Canada. In Knight, R.J. and McLean, J.R. (Editors) Shelf Sands and Sandstones, CSPG Memoir II.

Luternauer, J.L., Clague, J.J., Conway, K.W., Barrie, J.V., Blaise, B., and Mathewes, R.W. 1989. Late Pleistocene terrestrial deposits on the continental shelf of western Canada: evidence for rapid sea-level change at the end of the last glaciation. Geology, v. 17, p. 357-360.

Luternauer, J.L. and Murray, J.W. 1983. Late Quaternary morphological development and sedimentation, central British Columbia continental shelf. Geological Survey of Canada Paper 83-21. 38 pp.

Marshall, J.F. and Davies, P.J. 1978. Skeletal carbonate variation on the continental shelf of eastern Australia. Bureau of Mineral Resources Journal of Geology and Geophysics, v. 3, p. 85-92.

McCartan, L., Tiffney, B.H., Wolfe, J.A., Ager, T.A., Wing, S.L. and Brooks, J. Late Tertiary floral assemblage from upland gravel deposits of the southern Maryland coastal plain. Geology, v. 18, p. 311-314.

McLusky, D.S. and McIntyre, A.D. Characteristics of the benthic fauna. **In:** Postma, H. and Zijlstra, J.J., Ecosystems of the World 27--Continental Shelves. p. 131- 154.

Merefield, J.R. 1984. Modern cool-water beach sands of southwest England. Journal of Sedimentary Petrology, v. 54, p. 413-424.

Milliman, J.D., Weiler, Y. and Stanley, D.J. 1972. Morphology and carbonate sedimentation on shallow banks in the Alboran Sea. **In:** D.J. Stanley (Editor), The Mediterranean Sea. Dowden, Hutchinson and Ross, Stroudsburg, Pa., p. 241-259.

Moslow, T.F., Barrie, J.V. and Luternauer, J.L. 1989. Sedimentary facies of a high-energy, tide-dominated continental shelf, Western Canada. In: Reinson, G.E. (Editor), Modern and Ancient Examples of Clastic Tidal Deposits - a Core and Peel Workshop. Canadian Society of Petroleum Geologists, Calgary. p. 25-36.

Muller, J. and Milliman, J.D. 1973. Relict carbonate rich sediments on southwestern Grand Bank, Newfoundland. Canadian Journal of Earth Sciences, v. 10, p. 1744-1750.

Nelson, C.S. 1978. Temperate shelf carbonates in the Cenozoic of New Zealand. Sedimentology, v. 25, p. 737-771.

Nelson, C.S. 1988. An introductory perspective on non-tropical shelf carbonates. Sedimentary Geology, v. 60, p. 3-12.

Nelson, C.S. and Bornhold, B.D. 1983. Temperate skeletal carbonate sediments on Scott shelf, northwestern Vancouver Island, Canada. Marine Geology, v. 52, p. 242-266.

Nelson, C.S., Hancock, G.E. and Kamp, P.J.J. 1982. Shelf to basin, temperate skeletal carbonate sediments, Three Kings Plateau, New Zealand. Journal of Sedimentary Petrology, v. 52, p. 717-732.

Nelson, C.S., Harris, G.J. and Young, H.R. 1988a. Burial-dominated cementation in non-tropical carbonates of the Oligocene Te Kuiti Group, New Zealand, Sedimentary Geology, v. 60 p. 233-250.

Nelson, C.S., Keane, S.L., and Head, P.S. 1988b. Non-tropical carbonate deposits on the modern New Zealand shelf. Sedimentary Geology, v. 60, p. 233-250.

Nelson, C.S. and Lawrence, M.F. Methane-derived high-Mg calcite submarine cement from the Fraser Delta, British Columbia, Canada. Sedimentology, v. 31, p. 645-654.

Niino, H. and Emery, K.O. 1966. Continental shelf sediments off northeastern Asia. Journal of Sedimentary Petrology, v. 36, p. 152-161.

Odin, G.S. and Matter, A. 1981. De glauconarium orignine. Sedimentology, v. 28, p. 611-641.

Pelletier, W.R. and Hyde, W. 1984. A model of the ice age cycle. In Milankovitch and Climate edited by A.Berger, J.Imbrie, J. Hays, G. Kukla and B. Saltzman. NATO ASI Series C: Mathematical and Physical Sciences, v. 126. p. 565-580.

Pollard, D. Some Ice-Age aspects of a calving ice sheet model. In Milankovitch and Climate edited by A.Berger, J.Imbrie, J. Hays, G. Kukla and B. Saltzman. NATO ASI Series C: Mathematical and Physical Sciences, v. 126. p. 541-564.

Posamentier, H.W. and Vail, P.R. Eustatic controls on clastic deposition II--sequence and systems tract models. In C.K. Wilgus, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, and J.C. Van Wagoner (Editors), Sea Level Changes: an Integrated Approach. p. 125-154.

Postma, H. 1988. Physical and chemical oceanographic aspects of continental shelves. **In:** Ecosystems of the World 27--Continental Shelves, Edited by Postma, H. and Zijlstra, J.J., p. 5-37.

Quilty, P.J. 1977. Cenozoic sedimentation cycles in Western Australia. Geology, v. 5, p. 336-340.

Quilty, P.J. 1980. Sedimentation cycles in the Cretaceous and Cenozoic of Western Australia. Tectonophysics, v. 63, p. 349-366.

Rao, C.P. 1981. Criteria for recognition of cold-water carbonate sedimentation: Berriedale Limestone (Lower Permian), Tasmania, Australia. Journal of Sedimentary Petrology, v. 51, p. 491-506.

Rao, C.P. 1988. Paleoclimate of some Permo-Triassic carbonates of Malaysia. Sedimentary Geology, v. 60, p. 163-171.

Reeckman, S.A. 1988. Diagenetic alterations in temperate shelf carbonates from southeastern Australia. Sedimentary Geology, v. 60, p. 209-219.

Reeckman, S.A. and Gill, E.D. 1981. Rates of vadose diagenesis in Quaterenary dune and shallow marine calcarenites. Warnambool, Victoria, Australia. Sedimentary Geology, v. 30, p. 157-172.

Rodgers, J. 1957. The distribution of marine carbonate sediments: a review. In: R.J. Le Blanc and J.G. Breeding (Editors), Regional Aspects of Carbonate Deposition. Society of Economic Paleontologists and Mineralogists, Special Publication 5, p. 2-13.

Scoffin, T.P. 1988. The environments of production and deposition of calcareous sediments on the shelf west of Scotland. Sedimentary Geology, v. 60, p. 107-124.

Shouldice, D.H. 1973. Western Canadian continental shelf. In R.D. McCrosson (editor), Future Petroleum Provinces of Canada: Their Geology and Potential. Canadian Society of Petroleum Geologists, Memoir I, p. 7-35.

Siesser, W.G. 1971. Mineralogy and diagenesis of some South African coastal and marine carbonates. Marine Geology, v. 10, p. 15-38.

Simone, L. and Carannante, G. 1988. The fate of foramol ("temperate-type") carbonate platforms. Sedimentary Geology, v. 60, p. 347-354.

Smith, A.M. 1988. Preliminary steps toward formation of a generalized budget for cold water carbonates. Sedimentary Geology, v. 60, p. 323-331.

Smith, S.V. 1971. Budget of calcium carbonate, southern California continental borderland. Journal of Sedimentary Petrology, v. 41, p. 798-808.

Studencki, W. 1979. Sedimentation of algal limestones from Busko Spa environs (Middle Miocene, Central Poland). Palaeogeography, Palaeoclimatology, Palaeoecology, v. 27, p. 155-165.

Sugden, D.E. and John, B.S. 1976. Glaciers and landscape. Butler and Tanner, Ltd. London. 376 p.

Thomson, R.E. 1981. Oceanography of the British Columbia Coast. Canadian Special Publication of Fisheries and Oceans 56. 291 p.

Van Wagoner, J.C., Posamentier, H.W., Mitchum, Jr., R.M., Vail, P.R., Sarg, J.F., Loutit, T.S. and Hardenbol, J. 1988. An overview of the fundamentals of sequence stratigraphy and key definitions. In C.K. Wilgus, C.G.St.C. Kendall, H.W. Posamentier, C.A. Ross, and J.C. Van Wagoner (Editors), Sea Level Changes: an Integrated Approach. p. 39-45.

Vicalvi, M.A. and Milliman, J.D. 1977. Calcium carbonate sedimentation on continental shelf off southern Brazil, with special reference to benthic foraminifera. American Association of Petroleum geology, Stud. Geol., v.4, p. 313-328.

Waas, R.E., Conolly, J.R. and MacIntyre, R.J. 1970. Bryozoan carbonate sand continuous along southern Australia. Marine Geology, v. 9, p. 63-73.

Walter, L.M. and Morse, J.W. 1984. Reactive surface area of skeletal carbonates during dissolution: effect of grain size. Journal of Sedimentary Petrology, v. 54, p. 1081-1090.

Warner, B.G., Mathewes, R.W. and Clague, J.J. 1982. Ice-free conditions on the Queen Charlotte Islands, British Columbia, at the Height of Late Wisconsin Glaciation. Science, v. 218, p. 675-677

West, I.M. 1973. Carbonate cementation of some Pleistocene temperate marine sediments. Sedimentology, v. 20, p. 229-249.

Wilson, J.B. 1979. Biogenic carbonate sediments on the Scottish continental shelf and on Rockall Bank. Marine Geology, v. 33, p. M85-M93

Wilson, J.B. 1981. Shelly faunas associated with temperate offshore tidal deposits. In Stride (Editor), Offshore Tidal Sands.

Wilson, J.B. 1988. A model for temporal changes in the faunal composition of shell gravels during a transgression on the continental shelf around the British Isles. Sedimentary Geology, v. 60, p.

Wilson, J.L. 1975. Carbonate facies in geologic history. New York, Springer-Verlag, 471 pp.

Wright, R.H. 1982. Late Pleistocene marine fauna, Goleta, California. Journal of Paleontology, v. 46, p. 688-695.

Yorath, C.J., Bornhold, B.D. and Thomson, R.E. 1979. Oscillation ripples on the northeast Pacific continental shelf. Marine Geology, v. 31, p. 45-58.

Young, H.R. and Nelson, C.S. 1985. Biodegradation of temperate-water skeletal carbonates by boring sponges on the Scott Shelf, British Columbia, Canada. Marine Geology, v. 65, p.33-45.

Young, H.R. and Nelson, C.S. 1988. Endolithic biodegradation of cool-water skeletal carbonates on Scott Shelf, northwestern Vancourver Island, Canada. Sedimentary Geology, v. 60, p. 251-267.

Ziegler, A.M., Hulver, M.L., Lottes, A.L., and Schmachtenberg, W.F. 1984. Uniformitarianism and paleoclimates: inferences ufrom the distribution of carbonate rocks In P.J. Brenchley (Editor), Fossils and Climate. Wiley, Chichester, p. 3-25.

VIII. APPENDICES

A. Grab Sample Data: Locations, Grain Size, % $CaCO_3$

1. Hecate Strait

Explanation of Tables

All blank spaces in the table indicate that the sample has not been analysed for that column. Pebble lithology data for samples are in Appendix B, faunal data are in Appendix C.

SAMPLE NO. - the sample designation. The first letters in the designation give the ship which took the sample, the following numbers identify the year in which the sample was taken. If the ship was involved in more than one cruise that year, a following letter identifies the cruise on which the sample was taken. e.g. GBR79B-85 indicates that the sample was taken by the G.B. Reed in 1979, on the second cruise that year, and was the 85th sample taken on that cruise.

DEPTH - water depth at the sample location as determined by echo sounder expressed in metres.

MEAN SIZE - mean grain size of the sample, expressed in ϕ

GRAVEL, SAND, MUD - these are the % by weight of each component. Mud is defined as silt + clay.

% CACO3 SAND - the % weight loss on acidification of the sand fraction.

% CACO3 GRAVEL - the percentage of carbonate material in the gravel fraction based on visual estimate.

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR79A-69	53° 50.0'	130° 50.0'	97	
GBR79A-70	53° 45.0'	131° 0.0'	47	0.64
GBR79A-71	53° 45.0'	130° 52.6'	64	2.20
GBR79A-72	53° 45.0'	130° 50.8'	82	2.49
GBR79A-73	53° 45.0'	130° 49.7'	101	2.79
GBR79A-74	53° 45.0'	130° 47.5'	119	3.33
GBR79A-75	53° 45.0'	130° 45.3'	137	4.12
GBR79A-76	53° 40.0'	130° 50.0'	49	1.67
GBR79A-77	53° 40.0'	130° 47.2'	68	1.96
GBR79A-78	53° 40.0'	130° 46.0'	88	1.96
GBR79A-79	53° 40.0'	130° 45.8'	104	2.20
GBR79A-80	53° 40.0'	130° 45.5'	122	3.06
GBR79A-81	53° 40.0'	130° 44.5'	137	3.49
GBR79A-82	53° 38.0'	131° 10.0'	44	1.91
GBR79A-83	53° 38.0'	131° 7.2'	60	2.00
GBR79A-84	53° 38.0'	131° 6.7'	48	-0.51
GBR79A-85	53° 38.0'	131° 5.3'	53	0.72
GBR79A-86	53° 38.0'	131° 4.7'	71	2.01
GBR79A-87	53° 38.0'	131° 4.0'	57	0.86
GBR79A-88	53° 38.0'	131° 3.0'	77	2.19
GBR79A-89	53° 38.0'	131° 2.1'	50	0.42
GBR79A-90	53° 38.0'	131° 0.0'	59	0.30
GBR79A-91	53° 36.0'	131° 0.0'	46	-3.06
GBR79A-92	53° 36.0'	131° 1.8'	40	-2.70
GBR79A-93	53° 36.0'	131° 3.8'	37	-3.87
GBR79A-94	53° 36.0'	131° 5.1'	42	-1.93
GBR79A-95	53° 36.0'	131° 6.8'	66	1.50
GBR79A-96	53° 36.0'	131° 8.8'	55	0.81
GBR79A-97	53° 36.0'	131° 10.0'	40	-3.22
GBR79A-98	53° 34.0'	131° 10.0'	55	1.84
GBR79A-99	53° 34.0'	131° 8.3'	66	1.97
GBR79A-100	53° 34.0'	131° 7.5'	62	0.80
GBR79A-101	53° 34.0'	131° 6.5'	46	-3.83
GBR79A-102	53° 34.0'	131° 4.0'	46	-3.29
GBR79A-103	53° 34.0'	131° 0.0'	49	-3.72
GBR79A-104	53° 32.0'	131° 0.0'	53	0.01
GBR79A-105	53° 32.0'	131° 2.5'	50	-4.18
GBR79A-106	53° 32.0'	131° 5.2'	39	-4.85
GBR79A-107	53° 32.0'	131° 7.8'	40	-2.83
GBR79A-108	53° 32.0'	131° 8.5'	55	1.36
GBR79A-109	53° 32.0'	131° 10.0'	71	1.70
GBR79A-110	53° 38.3'	131° 2.9'	68	-0.16
GBR79A-111	53° 40.0'	131° 0.0'	38	-3.26
GBR79A-112	53° 40.0'	131° 1.6'	42	-4.77
GBR79A-113	53° 40.0'	131° 3.4'	57	-0.73
GBR79A-114	53° 40.0'	131° 5.7'	46	-4.30
GBR79A-115	53° 40.0'	131° 6.8'	57	0.23
GBR79A-116	53° 40.0'	131° 9.1'	46	1.36
GBR79A-117	53° 40.0'	131° 10.0'	44	2.30
GBR79A-118	53° 39.0'	131° 10.0'	46	-2.65

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR79A-69					
GBR79A-70	16.7	81.1	2.2	3.5	95
GBR79A-71	0.0	98.1	1.9	<2.0	
GBR79A-72	0.0	97.8	2.2	<2.0	
GBR79A-73	0.2	96.1	3.7	<2.0	
GBR79A-74	0.0	91.9	8.1	<2.0	
GBR79A-75	0.0	82.7	17.3	<2.0	
GBR79A-76	0.3	97.8	1.9	2.0	
GBR79A-77	0.1	98.6	1.3	<2.0	
GBR79A-78	0.0	98.2	1.8	<2.0	
GBR79A-79	0.0	97.1	2.9	<2.0	
GBR79A-80	0.0	95.1	4.9	<2.0	
GBR79A-81	0.0	87.3	12.7	2.0	
GBR79A-82	3.2	94.0	2.8	23.0	
GBR79A-83	3.9	92.7	3.4	22.5	
GBR79A-84	34.9	62.8	2.3	25.0	
GBR79A-85	21.0	76.3	2.7	52.0	100
GBR79A-86	7.2	89.8	3.0	14.5	
GBR79A-87	17.6	79.0	3.4	75.0	
GBR79A-88	0.0	95.0	5.0	8.0	
GBR79A-89	26.0	72.3	1.7	57.5	
GBR79A-90	27.4	70.4	2.2	49.5	95
GBR79A-91	72.8	26.1	1.1	30.5	
GBR79A-92	60.2	39.3	0.5	18.5	
GBR79A-93	97.9	1.5	0.6	51.0	
GBR79A-94	70.3	29.3	0.4	16.5	
GBR79A-95	4.0	94.0	2.0	53.5	
GBR79A-96	20.2	76.9	2.9	15.5	15
GBR79A-97	71.4	27.1	1.5	28.0	
GBR79A-98	2.0	96.0	2.0	17.0	
GBR79A-99	1.1	97.2	1.7	31.5	
GBR79A-100	19.0	77.6	3.4	87.5	100
GBR79A-101	86.7	12.4	0.9	55.0	
GBR79A-102	81.8	17.3	0.9	71.5	
GBR79A-103	84.7	14.6	0.7	32.0	
GBR79A-104	32.9	66.1	1.0	6.5	
GBR79A-105	92.3	6.8	0.9	82.0	
GBR79A-106	89.3	10.1	0.6	60.0	
GBR79A-107	70.9	27.7	1.4	49.0	
GBR79A-108	3.4	95.3	1.3	45.5	
GBR79A-109	9.0	87.3	3.7	29.0	
GBR79A-110	43.5	41.1	15.4	11.0	
GBR79A-111	83.8	14.5	1.7	47.5	
GBR79A-112	95.5	3.3	1.2	56.5	
GBR79A-113	44.9	52.9	2.2	23.5	
GBR79A-114	87.6	11.1	1.3	44.5	
GBR79A-115	28.1	69.2	2.7	14.0	
GBR79A-116	12.1	84.2	3.7	27.5	
GBR79A-117	3.3	88.4	8.3	8.0	
GBR79A-118	69.4	27.7	2.9	18.0	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR79A-119	53° 39.0'	131° 9.3'	47	-0.35
GBR79A-120	53° 39.0'	131° 8.6'	42	0.37
GBR79A-121	53° 39.0'	131° 8.2'	47	1.62
GBR79A-122	53° 39.0'	131° 5.6'	44	1.83
GBR79A-123	53° 39.0'	131° 5.0'	47	-2.77
GBR79A-124	53° 39.0'	131° 3.8'	66	-0.15
GBR79A-125	53° 39.0'	131° 2.7'	47	-2.30
GBR79A-126	53° 39.0'	131° 0.0'	44	-3.72
GBR79A-127	53° 37.0'	131° 0.0'	46	1.05
GBR79A-128	53° 37.0'	131° 2.5'	38	-5.08
GBR79A-129	53° 37.0'	131° 3.8'	46	-0.57
GBR79A-130	53° 37.0'	131° 5.3'	47	0.63
GBR79A-131	53° 37.0'	131° 6.6'	58	1.63
GBR79A-132	53° 37.0'	131° 8.3'	44	-4.67
GBR79A-133	53° 37.0'	131° 10.0'	46	-0.22
GBR79A-134	53° 35.0'	131° 10.0'	58	1.90
GBR79A-135	53° 35.0'	131° 7.3'	60	1.31
GBR79A-136	53° 35.0'	131° 6.3'	42	-3.74
GBR79A-137	53° 35.0'	131° 4.4'	38	-4.06
GBR79A-138	53° 35.0'	131° 2.1'	40	-3.65
GBR79A-139	53° 35.0'	131° 0.0'	47	-4.19
GBR79A-140	53° 33.0'	131° 0.0'	49	-3.24
GBR79A-141	53° 33.0'	131° 2.8'	44	-2.51
GBR79A-142	53° 33.0'	131° 5.2'	33	-1.03
GBR79A-143	53° 33.0'	131° 6.3'	53	0.02
GBR79A-144	53° 33.0'	131° 8.0'	53	-1.67
GBR79A-145	53° 33.0'	131° 8.5'	62	1.48
GBR79A-147	53° 33.0'	131° 10.0'	44	
GBR79A-148	53° 31.0'	131° 10.0'	31	0.58
GBR79A-149	53° 31.0'	131° 9.5'	49	0.81
GBR79A-150	53° 31.0'	131° 7.8'	42	
GBR79A-151	53° 31.0'	131° 6.0'	42	-1.71
GBR79A-152	53° 0.0'	131° 0.0'	25	-1.78
GBR79A-153	53° 0.0'	130° 55.0'	29	1.47
GBR79A-154	53° 0.0'	130° 54.7'	31	-0.38
GBR79A-155	53° 0.0'	130° 54.2'	33	1.59
GBR79A-156	53° 0.0'	130° 52.2'	29	1.17
GBR79A-157	53° 0.0'	130° 51.3'	57	1.48
GBR79A-158	53° 0.0'	130° 49.0'	75	2.92
GBR79A-159	53° 0.0'	130° 46.9'	86	3.26
GBR79A-160	53° 0.0'	130° 44.2'	98	3.24
GBR79A-161	53° 0.0'	130° 42.3'	113	
GBR79A-162b	53° 0.0'	130° 41.4'	139	1.93
GBR79A-163b	53° 0.0'	130° 39.5'	133	3.93
GBR79A-164	53° 0.0'	130° 37.1'	122	4.32
GBR79A-165	53° 0.0'	130° 35.7'	92	2.75
GBR79A-166	53° 0.0'	130° 33.1'	93	1.29
GBR79A-167	53° 0.0'	130° 31.1'	117	3.65
GBR79A-168	53° 0.0'	130° 30.0'	122	2.67
GBR79A-169	52° 55.9'	130° 37.2'	88	2.05

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR79A-119	35.4	60.7	3.9	18.0	
GBR79A-120	18.7	78.3	3.0	10.5	
GBR79A-121	10.2	87.0	2.8	10.0	
GBR79A-122	3.0	95.9	1.1	10.5	
GBR79A-123	77.3	19.6	3.1	48.0	
GBR79A-124	42.0	31.7	26.3	14.5	
GBR79A-125	64.0	34.5	1.5	10.5	
GBR79A-126	82.2	16.1	1.7	40.0	
GBR79A-127	13.5	85.0	1.5	25.0	
GBR79A-128	98.2	1.3	0.5	84.5	
GBR79A-129	39.3	59.4	1.3	28.0	
GBR79A-130	20.0	78.0	2.0	57.0	
GBR79A-131	7.9	89.6	2.5	14.5	
GBR79A-132	89.3	10.2	0.5	22.0	1
GBR79A-133	32.2	64.5	3.3	31.0	
GBR79A-134	10.7	84.0	5.3	13.5	
GBR79A-135	10.5	85.1	4.4	50.5	
GBR79A-136	84.7	14.5	0.8	28.5	
GBR79A-137	83.7	15.4	0.9	73.0	
GBR79A-138	87.3	10.6	2.1	54.0	
GBR79A-139	97.7	1.7	0.6	78.0	
GBR79A-140	85.5	12.5	2.0	16.0	
GBR79A-141	69.7	27.3	3.0	56.5	
GBR79A-142	50.5	46.5	3.0	50.5	
GBR79A-143	33.2	65.1	1.7	53.5	
GBR79A-144	68.3	28.2	3.5	79.0	
GBR79A-145	4.6	92.3	3.1	62.5	
GBR79A-147					
GBR79A-148	12.5	86.9	0.6	7.5	
GBR79A-149	15.4	82.9	1.7	50.5	
GBR79A-150					
GBR79A-151	58.5	39.9	1.6	46.5	
GBR79A-152	55.6	44.2	0.2	21.5	
GBR79A-153	2.0	97.0	1.0	28.5	90
GBR79A-154	31.5	68.3	0.2	13.0	10
GBR79A-155	0.4	98.9	0.7	5.5	
GBR79A-156	3.0	93.3	3.7	7.5	
GBR79A-157	4.0	94.8	1.2	62.5	80
GBR79A-158	0.0	96.6	3.4	4.0	
GBR79A-159	0.0	92.7	7.3	4.5	
GBR79A-160	0.0	92.9	7.1	13.1	
GBR79A-161					
GBR79A-162b	0.0	94.6	5.4	2.0	
GBR79A-163b	0.0	73.3	26.7	<1.0	
GBR79A-164	0.0	61.3	38.7	<1.0	
GBR79A-165	3.8	81.6	14.6	2.0	
GBR79A-166	15.6	74.0	10.4	<1.0	
GBR79A-167	0.0	86.3	13.7	<1.0	
GBR79A-168	0.0	94.6	5.4	<1.0	
GBR79A-169	0.0	98.6	1.4	<1.0	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR79A-170	52 ° 58.0 '	130 ° 35.0 '	119	-0.94
GBR79A-171	52 ° 58.0 '	130 ° 36.8 '	121	1.60
GBR79A-172	52 ° 58.0 '	130 ° 38.8 '	75	0.54
GBR79A-173	52 ° 58.0 '	130 ° 39.7 '	60	0.64
GBR79A-174	52 ° 58.0 '	130 ° 41.3 '	55	-2.38
GBR79A-175	52 ° 58.0 '	130 ° 43.3 '	59	
GBR79A-176	52 ° 58.0 '	130 ° 44.2 '	66	1.50
GBR79A-177	52 ° 58.0 '	130 ° 45.0 '	64	1.80
GBR79A-178	52 ° 56.0 '	130 ° 45.0 '	48	-0.14
GBR79A-179	52 ° 56.0 '	130 ° 43.6 '	53	-0.54
GBR79A-180	52 ° 56.0 '	130 ° 42.3 '	55	1.14
GBR79A-181	52 ° 56.0 '	130 ° 41.8 '	55	-4.76
GBR79A-182	52 ° 56.1 '	130 ° 39.3 '	70	0.43
GBR79A-183	52 ° 56.0 '	130 ° 37.9 '	81	1.46
GBR79A-184	52 ° 56.0 '	130 ° 37.0 '	93	1.50
GBR79A-185	52 ° 56.0 '	130 ° 36.0 '	99	1.34
GBR79A-186	52 ° 56.0 '	130 ° 35.0 '	102	1.90
GBR79A-187	52 ° 54.0 '	130 ° 35.0 '	104	2.51
GBR79A-188b	52 ° 54.0 '	130 ° 36.3 '	93	2.97
GBR79A-189	52 ° 54.0 '	130 ° 37.8 '	88	1.10
GBR79A-190	52 ° 54.0 '	130 ° 38.9 '	77	-0.04
GBR79A-191	52 ° 54.0 '	130 ° 41.2 '	66	1.11
GBR79A-192	52 ° 54.0 '	130 ° 43.2 '	57	-0.85
GBR79A-193	52 ° 54.0 '	130 ° 44.5 '	57	-0.42
GBR79A-194	52 ° 54.0 '	130 ° 45.0 '	55	-0.70
GBR79A-195b	53 ° 2.9 '	130 ° 44.0 '	133	3.61
GBR79A-196	53 ° 2.1 '	130 ° 44.0 '	126	1.71
GBR79A-197	53 ° 1.1 '	130 ° 44.0 '	108	3.52
GBR79A-198	53 ° 0.1 '	130 ° 44.0 '	104	3.49
GBR79A-199	52 ° 59.1 '	130 ° 44.0 '	91	2.22
GBR79A-200	52 ° 58.8 '	130 ° 44.0 '	82	2.14
GBR79A-201	52 ° 58.5 '	130 ° 44.0 '	73	1.37
GBR79A-202	52 ° 58.0 '	130 ° 44.0 '	64	1.20
GBR79A-203	52 ° 57.0 '	130 ° 44.0 '	55	0.84
GBR79A-204	52 ° 57.0 '	130 ° 42.0 '	55	1.42
GBR79A-205	52 ° 57.9 '	130 ° 42.0 '	55	-0.25
GBR79A-206	52 ° 58.8 '	130 ° 42.0 '	70	0.06
GBR79A-207	52 ° 59.0 '	130 ° 42.0 '	89	1.50
GBR79A-208	52 ° 59.6 '	130 ° 42.0 '	106	3.03
GBR79A-209	53 ° 0.8 '	130 ° 42.0 '	128	3.29
GBR79A-210	53 ° 1.0 '	130 ° 42.0 '	146	1.82
GBR79A-211	53 ° 1.6 '	130 ° 42.0 '	121	4.10
GBR79A-212	53 ° 3.0 '	130 ° 42.0 '	113	3.36
GBR79A-213	53 ° 3.0 '	130 ° 40.0 '	106	2.83
GBR79A-214	53 ° 1.6 '	130 ° 40.0 '	124	4.35
GBR79A-215	53 ° 0.6 '	130 ° 40.0 '	128	4.27
GBR79A-216	53 ° 0.2 '	130 ° 40.0 '	145	2.94
GBR79A-217	52 ° 59.4 '	130 ° 40.0 '	137	3.59
GBR79A-218	52 ° 58.8 '	130 ° 40.0 '	108	1.65
GBR79A-219	52 ° 58.6 '	130 ° 40.0 '	77	1.22

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR79A-170	59.7	32.4	7.9	14.5	
GBR79A-171	0.0	98.4	1.6	<1.0	
GBR79A-172	10.0	89.5	0.5	<1.0	
GBR79A-173	17.0	81.1	1.9	<1.0	
GBR79A-174	67.5	32.2	0.3	2.5	
GBR79A-175					
GBR79A-176	0.0	99.1	0.9	5.0	
GBR79A-177	0.0	97.6	2.4	7.5	
GBR79A-178	30.2	68.6	1.2	42.5	50
GBR79A-179	35.3	64.3	0.4	7.5	
GBR79A-180	4.9	94.0	1.1	16.5	80
GBR79A-181	95.3	3.9	0.8	26.3	
GBR79A-182	10.3	89.2	0.5	<1.0	
GBR79A-183	2.2	96.4	1.4	<1.0	
GBR79A-184	0.5	99.3	0.2	<1.0	
GBR79A-185	4.9	91.4	3.7	2.0	
GBR79A-186	12.2	79.0	8.8	6.5	
GBR79A-187	0.0	96.5	3.5	<1.0	
GBR79A-188b	0.0	92.9	7.1	1.0	
GBR79A-189	15.9	79.4	4.7	4.5	
GBR79A-190	38.7	56.9	4.4	16.0	
GBR79A-191	11.7	70.9	17.4		
GBR79A-192	44.2	55.3	0.5	6.5	
GBR79A-193	42.3	55.7	2.0	45.5	70
GBR79A-194	55.0	43.1	1.9	65.0	90
GBR79A-195b	0.0	85.1	14.9	<1.0	
GBR79A-196	0.0	98.1	1.9	<1.0	
GBR79A-197	0.0	68.4	31.6	4.5	
GBR79A-198	1.1	70.8	28.1		
GBR79A-199	0.0	97.8	2.2	3.5	
GBR79A-200	0.0	91.1	8.9	3.0	
GBR79A-201	0.1	98.8	1.1	2.5	
GBR79A-202	1.3	98.1	0.6	3.0	
GBR79A-203	10.1	87.9	2.0	40.0	60
GBR79A-204	0.6	98.0	1.4	3.5	
GBR79A-205	33.3	66.1	0.6	2.5	
GBR79A-206	32.6	66.9	0.5	<1.0	
GBR79A-207	1.4	97.4	1.2	8.0	
GBR79A-208	0.0	90.3	9.7		
GBR79A-209	0.0	81.2	18.8		
GBR79A-210	22.8	67.4	9.8	12.0	
GBR79A-211	0.0	68.1	31.9	<1.0	
GBR79A-212	0.0	91.7	8.3	<1.0	
GBR79A-213	0.0	95.6	4.4	<1.0	
GBR79A-214	0.0	61.9	38.1	<1.0	
GBR79A-215	0.0	67.8	32.2	<1.0	
GBR79A-216	0.0	91.3	8.7	1.5	
GBR79A-217	0.0	86.7	13.3	4.0	
GBR79A-218	0.3	96.7	3.0	<1.0	
GBR79A-219	4.1	94.5	1.4	<1.0	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR79A-220	52 ° 58.4 '	130 ° 40.0 '	62	1.11
GBR79A-221	52 ° 58.1 '	130 ° 40.0 '	59	0.14
GBR79A-222	52 ° 57.7 '	130 ° 40.0 '	62	1.03
GBR79A-223	52 ° 57.0 '	130 ° 38.0 '	62	0.13
GBR79A-224	52 ° 57.0 '	130 ° 38.0 '	81	1.17
GBR79A-225	52 ° 58.0 '	130 ° 38.3 '	91	0.90
GBR79A-226	52 ° 58.3 '	130 ° 38.0 '	113	0.27
GBR79A-227	52 ° 58.6 '	130 ° 38.0 '	139	2.15
GBR79A-228	52 ° 59.5 '	130 ° 38.0 '	135	3.83
GBR79A-229b	53 ° 1.0 '	130 ° 38.0 '	120	2.68
GBR79A-230	53 ° 1.7 '	130 ° 38.0 '	104	-1.16
GBR79A-231a	53 ° 2.4 '	130 ° 38.0 '	106	2.76
GBR79A-232	53 ° 3.0 '	130 ° 38.0 '	102	2.64
GBR79A-233	53 ° 0.0 '	131 ° 0.0 '	33	0.00
GBR79A-234	53 ° 0.0 '	131 ° 5.0 '	31	1.24
GBR79A-235	53 ° 0.0 '	131 ° 10.0 '	29	2.59
GBR79A-236	53 ° 0.0 '	131 ° 15.0 '	27	2.03
GBR79A-237	53 ° 0.0 '	131 ° 20.0 '	22	2.21
GBR79A-238	52 ° 57.5 '	131 ° 20.0 '	22	
GBR79A-239	52 ° 55.0 '	131 ° 20.0 '	44	-1.82
GBR79A-240	52 ° 55.0 '	131 ° 15.0 '	26	-5.98
GBR79A-241	52 ° 55.0 '	131 ° 10.0 '	26	-3.59
GBR79A-242	52 ° 55.0 '	131 ° 5.0 '	29	-1.41
GBR79A-243	52 ° 55.0 '	131 ° 0.0 '	31	-0.73
GBR79A-244	52 ° 52.5 '	131 ° 0.0 '	31	-1.21
GBR79A-245	52 ° 50.0 '	131 ° 0.0 '	29	-2.89
GBR79A-246	52 ° 50.0 '	131 ° 5.0 '	27	-2.59
GBR79A-247	52 ° 50.0 '	131 ° 10.0 '	26	-2.11
GBR79A-248	52 ° 50.0 '	131 ° 15.0 '	22	-2.33
GBR79A-249	52 ° 50.0 '	131 ° 20.0 '	88	-0.12
GBR79A-250	52 ° 47.5 '	131 ° 20.0 '	95	-0.73
GBR79A-251	52 ° 45.0 '	131 ° 20.0 '	174	3.05
GBR79A-252	52 ° 45.0 '	131 ° 15.0 '	110	2.13
GBR79A-253	52 ° 45.0 '	131 ° 15.0 '	126	1.22
GBR79A-254	52 ° 45.0 '	131 ° 5.0 '	40	
GBR79A-255	52 ° 45.0 '	131 ° 0.0 '	38	-3.75
GBR79A-256	52 ° 42.5 '	131 ° 0.0 '	55	
GBR79A-257	52 ° 40.0 '	131 ° 0.0 '	68	-2.33
GBR79A-258	52 ° 40.0 '	131 ° 5.0 '	71	
GBR79A-259	52 ° 40.0 '	131 ° 10.0 '	80	-3.21
GBR79A-260	52 ° 39.2 '	131 ° 10.0 '	67	-0.92
GBR79A-261	52 ° 38.0 '	131 ° 10.0 '	78	3.63
GBR79A-262	52 ° 37.5 '	131 ° 10.0 '	95	1.70
GBR79A-263	52 ° 37.2 '	131 ° 10.0 '	102	1.90
GBR79A-264	52 ° 36.5 '	131 ° 10.0 '	126	1.22
GBR79A-265	52 ° 35.0 '	131 ° 10.0 '	144	
GBR79A-266	52 ° 35.0 '	131 ° 5.0 '	100	1.95
GBR79A-267	52 ° 37.0 '	131 ° 5.3 '	108	0.67
GBR79A-268	52 ° 37.4 '	131 ° 5.5 '	100	-0.31
GBR79A-269	52 ° 38.0 '	131 ° 5.6 '	86	-1.08

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR79A-220	5.7	92.8	1.5	<1.0	
GBR79A-221	29.6	69.9	0.5	<2.0	
GBR79A-222	6.8	92.6	0.6	<2.0	
GBR79A-223	22.6	76.9	0.5	<1.0	
GBR79A-224	0.4	98.8	0.8	<1.0	
GBR79A-225	17.6	80.6	1.8	2.5	
GBR79A-226	38.5	59.0	2.5	8.0	
GBR79A-227	0.0	97.6	2.4		
GBR79A-228	0.0	85.6	14.4	<1.0	
GBR79A-229b	0.0	92.3	7.7	<2.0	
GBR79A-230	56.5	37.5	6.0	14.0	
GBR79A-231a	0.0	96.1	3.9	<2.0	
GBR79A-232	0.0	96.2	3.8	<1.0	
GBR79A-233	36.9	62.4	0.7	28.0	15
GBR79A-234	4.8	89.0	6.2	<1.0	
GBR79A-235	62.8	36.3	0.9	32.0	30
GBR79A-236	92.3	6.8	0.9	95.5	
GBR79A-237	88.9	9.9	1.2	61.5	
GBR79A-238					
GBR79A-239	53.8	44.2	2.0	49.5	90
GBR79A-240	98.7	0.8	0.5		
GBR79A-241	95.0	4.0	1.0	72.0	
GBR79A-242	60.7	38.6	0.7	11.2	
GBR79A-243	42.7	56.6	0.7	21.5	
GBR79A-244	49.8	49.3	0.9	21.5	50
GBR79A-245	73.6	25.5	0.9	36.5	
GBR79A-246	78.0	19.1	2.9	60.0	
GBR79A-247	80.7	18.5	0.8	15.5	
GBR79A-248	72.5	23.5	4.0	54.0	
GBR79A-249	42.5	51.7	5.8	18.5	
GBR79A-250	55.6	33.0	11.4	38.5	
GBR79A-251	0.0	97.7	2.3		
GBR79A-252	0.0	98.2	1.8	4.0	
GBR79A-253	14.3	83.5	2.2	5.5	
GBR79A-254					
GBR79A-255	86.3	11.8	1.9	55.0	
GBR79A-256					
GBR79A-257	72.4	24.0	3.6	37.5	
GBR79A-258					
GBR79A-259	88.8	10.5	0.7	14.0	
GBR79A-260	55.3	42.6	2.1	24.0	
GBR79A-261	0.0	68.4	31.6		
GBR79A-262	0.0	97.9	2.1		
GBR79A-263	0.0	97.9	2.1	<1.0	
GBR79A-264	24.0	71.8	4.2	2.0	
GBR79A-265					
GBR79A-266	7.2	88.1	4.7	2.5	
GBR79A-267	23.9	74.9	1.2	<1.0	
GBR79A-268	47.7	51.0	1.3	1.0	
GBR79A-269	64.3	32.9	2.8	26.5	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR79A-270	52° 39.2'	131° 5.2'	66	-3.61
GBR79A-271	52° 40.0'	131° 5.2'	69	-0.99
GBR79A-272	52° 40.0'	131° 0.0'	69	
GBR79A-273	52° 38.6'	131° 0.4'	77	1.94
GBR79A-274	52° 37.8'	131° 0.2'	84	-3.01
GBR79A-275	52° 36.4'	131° 0.1'	110	-1.38
GBR79A-276	52° 35.0'	131° 0.1'	110	2.26
GBR79B-4	53° 34.3'	131° 8.0'	73	2.11
GBR79B-5	53° 31.0'	131° 6.0'	40	-2.69
GBR79B-6	53° 31.0'	131° 4.7'	44	-0.26
GBR79B-7	53° 31.0'	131° 2.5'	44	-3.69
GBR79B-8	53° 31.0'	131° 0.9'	48	-3.33
GBR79B-9	53° 31.0'	130° 59.3'	59	0.37
GBR79B-10	53° 31.0'	130° 57.7'	70	0.47
GBR79B-11	53° 31.0'	130° 55.8'	81	0.79
GBR79B-12	53° 31.0'	130° 54.0'	90	1.84
GBR79B-13	53° 30.9'	130° 52.3'	93	2.17
GBR79B-14	53° 31.0'	130° 51.1'	95	0.82
GBR79B-15	53° 31.0'	130° 49.2'	99	2.31
GBR79B-16	53° 31.0'	130° 47.4'	112	2.31
GBR79B-19	52° 54.0'	130° 32.2'	110	2.50
GBR79B-20	52° 54.0'	130° 36.6'	94	2.78
GBR79B-21	52° 54.0'	130° 39.4'	73	
GBR79B-22	52° 54.0'	130° 45.0'	55	0.24
GBR79B-23	52° 40.0'	131° 0.0'	70	-4.09
GBR79B-24	52° 40.0'	131° 0.0'	71	-2.88
GBR79B-25	52° 40.0'	130° 58.2'	77	-0.98
GBR79B-26	52° 40.0'	130° 56.5'	84	-2.99
GBR79B-27	52° 40.0'	130° 54.7'	98	-1.97
GBR79B-28	52° 40.0'	130° 52.9'	97	-0.09
GBR79B-29	52° 40.0'	130° 51.2'	101	-0.53
GBR79B-30	52° 40.0'	130° 48.8'	104	2.09
GBR79B-31	52° 40.0'	130° 46.9'	110	2.33
GBR79B-32	52° 40.0'	130° 44.9'	114	2.17
GBR79B-33a	52° 40.0'	130° 43.8'	130	2.56
GBR79B-33b	52° 40.0'	130° 43.8'	130	2.61
GBR79B-34	52° 58.0'	131° 0.0'	30	1.38
GBR79B-35	52° 58.0'	130° 58.1'	29	0.37
GBR79B-36	52° 58.0'	130° 55.6'	33	1.57
GBR79B-37	52° 58.0'	130° 53.7'	35	1.06
GBR79B-38	52° 58.0'	130° 51.7'	37	1.61
GBR79B-39	52° 58.0'	130° 49.7'	55	1.66
GBR79B-40	52° 58.0'	130° 47.4'	62	2.03
GBR79B-41	52° 58.0'	130° 45.3'	64	1.71
GBR79B-42	52° 56.0'	130° 45.0'	48	-0.91
GBR79B-43	52° 56.0'	130° 47.5'	42	-2.33
GBR79B-44	52° 56.0'	130° 49.6'	46	1.41
GBR79B-45	52° 56.0'	130° 51.8'	37	-0.69
GBR79B-46	52° 56.0'	130° 54.0'	31	-0.70
GBR79B-47	52° 56.0'	130° 56.0'	31	-1.23

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR79A-270	88.8	10.0	1.2	56.0	
GBR79A-271	60.0	35.1	4.9	74.0	
GBR79A-272					
GBR79A-273	0.0	94.1	5.9		
GBR79A-274	71.9	26.0	2.1	36.5	
GBR79A-275	60.8	37.4	1.8	4.0	
GBR79A-276	0.2	97.9	1.9	<1.0	
GBR79B-4	0.0	97.7	2.3	27.0	
GBR79B-5	75.7	22.5	1.8	66.5	30
GBR79B-6	41.1	56.3	2.6	78.5	100
GBR79B-7	93.4	6.0	0.6	62.5	
GBR79B-8	93.4	6.0	0.6	61.0	
GBR79B-9	27.8	70.9	1.3	12.5	
GBR79B-10	25.2	73.8	1.0	3.5	
GBR79B-11	19.0	79.7	1.3	3.0	3
GBR79B-12	0.0	98.3	1.7	<2.0	
GBR79B-13	0.0	98.7	1.3	<2.0	
GBR79B-14	24.8	73.3	1.9	2.5	
GBR79B-15	0.0	98.0	2.0	<2.0	
GBR79B-16	0.0	97.7	2.3	<2.0	
GBR79B-19	0.0	87.6	12.4	1.6	
GBR79B-20	3.2	83.8	13.0	2.5	
GBR79B-21					
GBR79B-22	41.8	55.5	2.7	65.5	50
GBR79B-23	96.5	2.8	0.7		
GBR79B-24	86.4	12.4	1.2	51.0	
GBR79B-25	46.6	50	3.4	14.0	
GBR79B-26	82.7	15.2	2.1	45.0	
GBR79B-27	65.8	30.7	3.5	25.0	
GBR79B-28	33.0	65.1	1.9	1.0	
GBR79B-29	44.0	52.5	3.5	4.0	
GBR79B-30	0.0	98.3	1.7	<1.0	
GBR79B-31	0.0	97.3	2.7	<1.0	
GBR79B-32	0.0	97.9	2.1	<1.0	
GBR79B-33a	0.0	95.6	4.4	<1.0	
GBR79B-33b	0.0	94.3	5.7	<1.0	
GBR79B-34	2.7	96.5	0.8	9.0	95
GBR79B-35	20.6	78.6	0.8	21.5	60
GBR79B-36	2.8	96.2	1.0	17.6	95
GBR79B-37	8.0	91.0	1.0	21.0	99
GBR79B-38	0.9	97.8	1.3	6.5	
GBR79B-39	1.1	97.9	1.0	17.5	
GBR79B-40	0.0	98.8	1.2	9.5	
GBR79B-41	0.5	98.4	1.1	9.0	
GBR79B-42	49.6	49.4	1.0	23.0	
GBR79B-43	70.3	29.4	0.3	1.5	
GBR79B-44	2.6	96.5	0.9	9.5	100
GBR79B-45	58.0	41.3	0.7	14.0	
GBR79B-46	56.8	42.8	0.4	5.0	
GBR79B-47	51.2	48.1	0.7	20.0	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR79B-48	52 ° 56.0 '	130 ° 58.2 '	29	-0.97
GBR79B-49	52 ° 56.0 '	131 ° 0.0 '	31	1.37
GBR79B-50	53 ° 20.0 '	130 ° 54.0 '	123	0.23
GBR79B-51	53 ° 20.0 '	130 ° 55.6 '	97	1.24
GBR79B-52	53 ° 20.0 '	130 ° 57.6 '	88	1.75
GBR79B-53	53 ° 20.0 '	130 ° 59.7 '	81	2.04
GBR79B-54	53 ° 20.0 '	131 ° 1.4 '	71	1.93
GBR79B-55	53 ° 20.0 '	131 ° 3.5 '	55	-0.61
GBR79B-56	53 ° 20.0 '	131 ° 5.6 '	44	1.57
GBR79B-57	53 ° 20.0 '	131 ° 7.8 '	44	0.79
GBR79B-58	53 ° 20.0 '	131 ° 10.0 '	20	-1.60
GBR79B-59	53 ° 25.0 '	131 ° 9.0 '	27	-4.32
GBR79B-60	53 ° 25.0 '	131 ° 6.5 '	33	-4.54
GBR79B-61	53 ° 25.0 '	131 ° 4.6 '	46	1.82
GBR79B-62	53 ° 25.0 '	131 ° 2.6 '	57	1.81
GBR79B-63	53 ° 25.0 '	131 ° 0.2 '	77	2.46
GBR79B-64	53 ° 25.0 '	130 ° 57.8 '	98	2.34
GBR79B-65	53 ° 25.0 '	130 ° 55.6 '	108	2.28
GBR79B-66	53 ° 25.0 '	130 ° 53.6 '	128	-1.16
GBR79B-67	53 ° 25.0 '	130 ° 51.6 '	128	-2.51
GBR79B-68	53 ° 25.0 '	130 ° 49.8 '	155	3.50
GBR79B-69	53 ° 15.0 '	130 ° 48.5 '	150	3.96
GBR79B-70	53 ° 15.0 '	130 ° 50.5 '	122	1.96
GBR79B-71	53 ° 15.0 '	130 ° 52.2 '	121	2.41
GBR79B-72	53 ° 15.0 '	130 ° 53.7 '	112	2.50
GBR79B-73	53 ° 15.0 '	130 ° 55.7 '	97	2.50
GBR79B-74	53 ° 15.0 '	130 ° 57.5 '	90	-1.63
GBR79B-75	53 ° 15.0 '	130 ° 59.4 '	82	-3.15
GBR79B-76	53 ° 15.0 '	131 ° 1.3 '	68	0.79
GBR79B-77	53 ° 15.0 '	131 ° 3.3 '	42	1.41
GBR79B-78	53 ° 15.0 '	131 ° 5.4 '	40	-0.09
GBR79B-79	53 ° 15.0 '	131 ° 7.3 '	38	0.01
GBR79B-80	53 ° 10.0 '	131 ° 6.7 '	38	1.19
GBR79B-81	53 ° 10.0 '	131 ° 5.0 '	44	-1.16
GBR79B-82	53 ° 10.0 '	131 ° 3.3 '	46	1.57
GBR79B-83	53 ° 10.0 '	131 ° 1.7 '	46	
GBR79B-84	53 ° 10.0 '	131 ° 0.0 '	51	0.53
GBR79B-85	53 ° 10.0 '	130 ° 58.3 '	62	1.70
GBR79B-86	53 ° 10.0 '	130 ° 56.5 '	82	0.59
GBR79B-87	53 ° 10.0 '	130 ° 54.9 '	93	2.34
GBR79B-88	53 ° 10.0 '	130 ° 53.0 '	106	0.20
GBR79B-89	53 ° 10.0 '	130 ° 51.3 '	117	-1.13
GBR79B-90	53 ° 10.0 '	130 ° 49.5 '	124	-3.51
GBR79B-91	53 ° 10.0 '	130 ° 47.8 '	124	2.65
GBR79B-92	53 ° 10.0 '	130 ° 46.1 '	145	3.50
GBR79B-93	52 ° 50.0 '	131 ° 0.0 '	29	-2.99
GBR79B-94	52 ° 50.0 '	130 ° 54.7 '	46	0.10
GBR79B-95	52 ° 50.0 '	130 ° 49.7 '	59	-0.06
GBR79B-96	52 ° 50.0 '	130 ° 44.6 '	73	2.16
GBR79B-97	52 ° 50.0 '	130 ° 40.0 '	93	2.96

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR79B-48	44.7	54.7	0.6	34.5	
GBR79B-49	2.4	96.8	0.8	21.5	
GBR79B-50	32.4	64.1	3.5	3.5	
GBR79B-51	12.1	86.4	1.5	<1.0	
GBR79B-52	0.0	98.0	2.0	<2.0	
GBR79B-53	0.0	98.7	1.3	<2.0	
GBR79B-54	0.0	98.6	1.4	<2.0	
GBR79B-55	36.4	61.5	2.1	5.0	85
GBR79B-56	0.7	98.3	1.0	6.5	
GBR79B-57	19.5	79.3	1.2	9.5	
GBR79B-58	52.3	47.0	0.7	6.0	
GBR79B-59	94.9	5.1	0.0	80.5	
GBR79B-60	91.4	8.6	0.0	58.0	
GBR79B-61	2.9	84.3	12.8	2.5	
GBR79B-62	0.0	97.9	2.1	<2.0	
GBR79B-63	0.0	98.7	1.3	<2.0	
GBR79B-64	0.0	97.7	2.3	<2.0	
GBR79B-65	0.0	97.5	2.5	<2.0	
GBR79B-66	51.7	45.8	2.5	3.0	0
GBR79B-67	74.4	20.5	5.1	8.5	
GBR79B-68	0.0	84.8	15.2	<2.0	
GBR79B-69	0.0	74.7	25.3	<2.0	
GBR79B-70	0.1	95.9	4.0	<2.0	
GBR79B-71	0.0	95.7	4.3	<2.0	
GBR79B-72	0.0	95.8	4.2	2.5	
GBR79B-73	0.0	98.0	2.0	<2.0	
GBR79B-74	57.2	42.1	0.7	<2.0	
GBR79B-75	75.1	23.4	1.5	5.5	
GBR79B-76	23.0	74.7	2.3	4.5	
GBR79B-77	4.7	93.8	1.5	21.5	
GBR79B-78	32.6	66.5	0.9	15.0	10
GBR79B-79	28.3	71.1	0.6	24.2	
GBR79B-80	5.6	92.7	1.7	32.5	
GBR79B-81	49.8	49.5	0.7	5.5	
GBR79B-82	20.4	56.0	23.6	17.5	
GBR79B-83					
GBR79B-84	13.0	86.4	0.6	13.0	
GBR79B-85	11.7	75.5	12.8	5.5	
GBR79B-86	28.6	69.1	2.3	4.0	
GBR79B-87	0.0	97.5	2.5	<2.0	
GBR79B-88	38.7	58.6	2.7	3.0	
GBR79B-89	43.3	54.7	2.0	3.0	
GBR79B-90	94.9	3.9	1.2	19.0	
GBR79B-91	0.0	88.7	11.3	<2.0	
GBR79B-92	0.0	87.2	12.8	2.5	
GBR79B-93	85.2	14.8	0.0	38.5	
GBR79B-94	23.1	76.1	0.8	39.5	
GBR79B-95	31.2	68.2	0.6	<2.0	
GBR79B-96	0.0	98.1	1.9	<2.0	
GBR79B-97	0.1	96.2	3.7	1.5	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
VEC81B-1	52° 42.0'	130° 46.5'	106	2.26
VEC81B-2a	52° 42.0'	130° 43.5'	119	1.07
VEC81B-2b	52° 42.0'	130° 43.5'	119	-0.55
VEC81B-3	52° 42.0'	130° 40.0'	135	2.98
VEC81B-4	52° 42.0'	130° 36.6'	143	4.17
VEC81B-5	52° 42.0'	130° 33.5'	143	1.24
VEC81B-6a	52° 44.0'	130° 33.2'	140	-1.85
VEC81B-6b	52° 44.0'	130° 33.2'	140	1.54
VEC81B-7a	52° 44.0'	130° 36.6'	130	-2.76
VEC81B-7b	52° 44.0'	130° 36.6'	130	-3.62
VEC81B-8	52° 44.0'	130° 40.0'	124	1.05
VEC81B-9	52° 44.0'	130° 43.2'	110	-2.01
VEC81B-10	52° 44.0'	130° 46.5'	98	-0.41
VEC81B-11	52° 44.0'	130° 49.8'	90	1.31
VEC81B-12	52° 44.0'	130° 53.0'	80	0.22
VEC81B-13	52° 44.0'	130° 56.5'	61	-1.58
VEC81B-14a	52° 44.0'	131° 0.0'	48	-2.40
VEC81B-14b	52° 44.0'	131° 0.0'	48	-0.55
VEC81B-15	52° 44.0'	131° 3.1'	45	-3.29
VEC81B-16	52° 42.0'	131° 3.1'	54	-3.23
VEC81B-17a	52° 42.0'	131° 0.0'	61	-4.30
VEC81B-17b	52° 42.0'	131° 0.0'	61	-3.58
VEC81B-18	52° 42.0'	130° 56.5'	75	-0.46
VEC81B-19	52° 42.0'	130° 53.0'	91	1.23
VEC81B-20	52° 42.0'	130° 49.8'	102	2.02
VEC81B-21	52° 46.0'	130° 33.2'	143	2.27
VEC81B-22	52° 46.0'	130° 36.5'	131	3.53
VEC81B-23	52° 46.0'	130° 40.0'	117	3.01
VEC81B-24	52° 46.0'	130° 43.2'	108	2.60
VEC81B-25	52° 46.0'	130° 46.5'	95	
VEC81B-26	52° 46.0'	130° 49.8'	83	-0.44
VEC81B-27	52° 46.0'	130° 53.0'	70	-0.94
VEC81B-28	52° 46.0'	130° 56.5'	55	-0.80
VEC81B-29	52° 46.0'	131° 0.0'	41	-1.70
VEC81B-30	52° 46.0'	131° 3.1'	45	0.18
VEC81B-31	52° 34.0'	131° 13.0'	160	3.89
VEC81B-32	52° 34.0'	131° 9.5'	155	2.22
VEC81B-33	52° 34.0'	131° 6.3'	138	2.07
VEC81B-34	52° 34.0'	131° 3.0'	115	1.49
VEC81B-35	52° 34.0'	131° 0.0'	129	0.49
VEC81B-36	52° 34.0'	130° 56.5'	145	2.28
VEC81B-37a	52° 36.0'	130° 56.5'	95	-1.55
VEC81B-37b	52° 36.0'	130° 56.5'	95	-2.65
VEC81B-38	52° 38.0'	130° 56.5'	94	-1.83
VEC81B-39	52° 38.0'	130° 53.0'	102	-1.26
VEC81B-40a	52° 36.0'	130° 53.0'	105	-2.63
VEC81B-40b	52° 36.0'	130° 53.0'	105	-0.01
VEC81B-41	52° 34.0'	130° 53.0'	146	2.46
VEC81B-42	52° 34.0'	130° 49.8'	160	0.40
VEC81B-43	52° 36.0'	130° 49.8'	119	2.29

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
VEC81B-1	0.0	97.4	2.6	<2.0	
VEC81B-2a	24.0	69.8	6.2	<2.0	
VEC81B-2b	46.8	48.1	5.1	<2.0	
VEC81B-3	0.0	77.4	22.6	<2.0	
VEC81B-4	0.0	62.1	37.9	<2.0	
VEC81B-5	27.3	47.5	25.2	7.0	
VEC81B-6a	68.0	22.8	9.2	<2.0	
VEC81B-6b	6.4	79.9	13.7	<2.0	
VEC81B-7a	85.6	12.7	1.7		
VEC81B-7b	82.7	11.9	5.4	6.0	
VEC81B-8	25.5	59.5	15.0	<2.0	
VEC81B-9	65.5	29.2	5.3	3.5	
VEC81B-10	57.6	33.0	9.4	17.0	
VEC81B-11	6.1	92.7	1.2		
VEC81B-12	36.9	56.9	6.2	27.0	
VEC81B-13	62.8	36.4	0.8	8.0	
VEC81B-14a	61.3	37.8	0.9	16.5	
VEC81B-14b	51.6	46.1	2.3	64.6	95
VEC81B-15	71.6	27.7	0.7	41.5	90
VEC81B-16	87.0	12.5	0.5	48.5	
VEC81B-17a	91.7	6.7	1.6	84.5	
VEC81B-17b	84.4	13.5	2.1	76.0	
VEC81B-18	35.9	61.3	2.8	24.6	
VEC81B-19	5.8	92.6	1.6	<2.0	
VEC81B-20	0.0	98.1	1.9	<2.0	
VEC81B-21	18.6	43.4	38.0	<2.0	
VEC81B-22	0.0	60.5	39.5	<2.0	
VEC81B-23	0.0	80.7	19.3	<2.0	
VEC81B-24	0.0	93.4	6.6	<2.0	
VEC81B-25					
VEC81B-26	39.6	59.8	0.6	<2.0	
VEC81B-27	45.5	53.5	1.0	16.5	
VEC81B-28	46.3	52.9	0.8	18.0	
VEC81B-29	65.8	33.3	0.9	46.5	20
VEC81B-30	26.4	71.9	1.7	63.0	100
VEC81B-31	0.0	83.9	16.1	<2.0	
VEC81B-32	0.0	96.7	3.3	<2.0	
VEC81B-33	0.0	97.7	2.3	<2.0	
VEC81B-34	9.6	85.5	4.9	10.5	
VEC81B-35	32.5	61.8	5.7	8.0	
VEC81B-36	0.0	97.9	2.1	2.0	
VEC81B-37a	61.9	33.7	4.4	19.0	
VEC81B-37b	74.9	21.4	3.7	26.5	
VEC81B-38	57.6	38.6	3.8	39.0	
VEC81B-39	54.8	41.1	4.1	27.2	
VEC81B-40a	75.7	19.7	4.6	26.0	
VEC81B-40b	35.5	60.5	4.0	28.0	
VEC81B-41	0.0	96.7	3.3	<2.0	
VEC81B-42	25.1	71.6	3.3	<2.0	
VEC81B-43	0.0	97.8	2.2	4.0	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE φ
VEC81B-44	52 ° 38.0 '	130 ° 49.8 '	111	1.60
VEC81B-45	52 ° 38.0 '	130 ° 46.5 '	123	2.42
VEC81B-46	52 ° 36.0 '	130 ° 46.5 '	123	2.99
VEC81B-47	52 ° 34.0 '	130 ° 46.5 '	154	3.32
VEC81B-48	52 ° 34.0 '	130 ° 43.2 '	133	3.00
VEC81B-49	52 ° 36.0 '	130 ° 43.2 '	133	2.24
VEC81B-50	52 ° 38.0 '	130 ° 43.2 '	134	
VEC81B-51	52 ° 40.0 '	130 ° 40.0 '	140	3.11
VEC81B-52	52 ° 38.0 '	130 ° 40.0 '	141	3.99
VEC81B-53	52 ° 36.0 '	130 ° 40.0 '	136	3.00
VEC81B-54	52 ° 34.0 '	130 ° 40.0 '	138	2.91
VEC81B-55	52 ° 36.0 '	130 ° 36.5 '	146	3.32
VEC81B-56	52 ° 38.0 '	130 ° 36.5 '	144	2.16
VEC81B-57	52 ° 40.0 '	130 ° 36.5 '	150	2.65
VEC81B-58	52 ° 48.0 '	130 ° 33.2 '	130	3.03
VEC81B-59	52 ° 48.0 '	130 ° 36.5 '	122	4.08
VEC81B-60	52 ° 48.0 '	130 ° 40.0 '	105	3.44
VEC81B-61	52 ° 48.0 '	130 ° 43.2 '	90	1.19
VEC81B-62	52 ° 48.0 '	130 ° 43.2 '	82	1.56
VEC81B-63	52 ° 42.0 '	131 ° 9.5 '	71	-2.95
VEC81B-64	52 ° 44.0 '	131 ° 9.5 '	70	1.44
VEC81B-65	52 ° 46.0 '	131 ° 9.5 '	73	1.93
VEC81B-66	52 ° 48.0 '	131 ° 9.5 '	30	-2.81
VEC81B-67	52 ° 50.0 '	131 ° 9.5 '	23	-3.95
VEC81B-68a	52 ° 52.0 '	131 ° 9.5 '	25	-2.60
VEC81B-68b	52 ° 52.0 '	131 ° 9.5 '	25	-0.28
VEC81B-69	52 ° 54.0 '	131 ° 9.5 '	30	-1.98
VEC81B-70	52 ° 56.0 '	131 ° 9.5 '	25	-1.12
VEC81B-71	52 ° 58.0 '	131 ° 9.5 '	27	-1.53
VEC81B-72	53 ° 0.0 '	131 ° 9.5 '	28	-1.81
VEC81B-73	53 ° 2.0 '	131 ° 9.5 '	31	-1.13
VEC81B-74	53 ° 4.0 '	131 ° 9.5 '	37	-2.89
VEC81B-75	53 ° 4.0 '	131 ° 6.3 '	33	1.93
VEC81B-76	53 ° 2.0 '	131 ° 6.3 '	32	0.05
VEC81B-77	53 ° 0.0 '	131 ° 6.2 '	32	-0.35
VEC81B-78	52 ° 58.0 '	131 ° 6.2 '	30	-1.38
VEC81B-79	52 ° 57.0 '	131 ° 6.2 '	32	-0.53
VEC81B-80	52 ° 54.0 '	131 ° 6.3 '	32	0.16
VEC81B-81	52 ° 52.0 '	131 ° 6.3 '	32	-1.94
VEC81B-82	52 ° 50.0 '	131 ° 6.2 '	35	-3.01
VEC81B-83	52 ° 48.0 '	131 ° 6.2 '	33	-1.79
VEC81B-84	52 ° 46.0 '	131 ° 6.3 '	42	-2.62
VEC81B-85	52 ° 44.0 '	131 ° 6.3 '	50	-2.89
VEC81B-86	52 ° 42.0 '	131 ° 6.1 '	50	-3.67
VEC81B-87	52 ° 36.0 '	131 ° 13.0 '	133	0.86
VEC81B-88	52 ° 38.2 '	131 ° 13.0 '	110	
VEC81B-89	52 ° 40.1 '	131 ° 13.0 '	83	-0.06
VEC81B-90	52 ° 42.1 '	131 ° 13.0 '	68	-0.46
VEC81B-91	52 ° 44.0 '	131 ° 13.0 '	96	-0.51
VEC81B-92	52 ° 46.0 '	131 ° 13.0 '	100	2.42

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SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
VEC81B-44	0.5	97.1	2.4	<2.0	
VEC81B-45	0.0	93.8	6.2	<2.0	
VEC81B-46	0.0	91.7	8.3	<2.0	
VEC81B-47	0.0	90.0	10.0	<2.0	
VEC81B-48	0.0	90.6	9.4	<2.0	
VEC81B-49	0.0	88.5	11.5	<2.0	
VEC81B-50					
VEC81B-51	0.0	77.0	23.0	<2.0	
VEC81B-52	0.0	76.0	24.0	<2.0	
VEC81B-53	0.0	91.6	8.4	<2.0	
VEC81B-54	0.0	91.0	9.0	<2.0	
VEC81B-55	0.0	79.4	20.6	<2.0	
VEC81B-56	2.1	81.3	16.6	<2.0	
VEC81B-57	0.5	81.1	18.4	<2.0	
VEC81B-58	0.0	77.8	22.2	<2.0	
VEC81B-59	0.0	64.3	35.7	<2.0	
VEC81B-60	0.0	83.6	16.4	<2.0	
VEC81B-61	22.6	71.8	5.6	5.0	
VEC81B-62	0.1	98.4	1.5	<2.0	
VEC81B-63	72.4	27.4	0.2	22.5	10
VEC81B-64	11.7	84.2	4.1	43.0	
VEC81B-65	3.0	95.1	1.9	31.0	100
VEC81B-66	72.8	26.8	0.4	31.5	
VEC81B-67	94.9	4.8	0.3	50.5	
VEC81B-68a	74.1	25.4	0.5	42.5	
VEC81B-68b	27.3	71.6	1.1	61.5	
VEC81B-69	57.6	42.0	0.4	55.0	
VEC81B-70	49.3	50.1	0.6	55.0	
VEC81B-71	60.8	38.3	0.9	32.5	
VEC81B-72	71.1	28.5	0.4	24.5	
VEC81B-73	57.8	41.6	0.6	33.0	
VEC81B-74	72.0	27.1	0.9	45.5	
VEC81B-75	0.0	97.9	2.1	14.5	
VEC81B-76	31.6	67.3	1.1	53.0	
VEC81B-77	35.9	63.6	0.5	22.5	
VEC81B-78	53.7	42.9	3.4	32.0	
VEC81B-79	37.1	62.3	0.6	24.0	
VEC81B-80	23.2	76.0	0.8	46.3	
VEC81B-81	75.5	24.0	0.5	45.0	
VEC81B-82	86.0	13.8	0.2	41.5	
VEC81B-83	59.2	40.7	0.1	71.0	
VEC81B-84	71.7	27.2	1.1	72.0	30
VEC81B-85	72.3	27.6	0.1	45.5	6
VEC81B-86	76.0	23.0	1.0	27.0	
VEC81B-87	29.9	62.4	7.7	<2.0	
VEC81B-88					
VEC81B-89	33.1	64.9	2.0	5.5	
VEC81B-90	41.9	55.8	2.3	26.0	
VEC81B-91	45.4	51.8	2.8	10.0	
VEC81B-92	0.0	95.5	4.5	3.0	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE Ø
VEC81B-93	52° 48.0'	131° 13.0'	36	-4.45
VEC81B-94b	52° 50.0'	131° 13.0'	28	-5.32
VEC81B-95	52° 50.0'	131° 16.3'	30	-2.41
VEC81B-96	52° 48.0'	131° 16.3'	72	0.17
VEC81B-97	52° 46.0'	131° 16.3'	84	-0.00
VEC81B-98	52° 44.1'	131° 16.3'	136	-0.90
VEC81B-99	52° 42.0'	131° 16.3'	150	1.71
VEC81B-100	52° 40.0'	131° 16.5'	150	1.90
VEC81B-101	52° 38.0'	131° 16.4'	133	-4.54
VEC81B-102	52° 36.0'	131° 16.4'	112	2.16
VEC81B-103	52° 34.0'	131° 16.4'	137	3.87
VEC81B-104	52° 48.0'	131° 3.1'	33	-1.44
VEC81B-105a	52° 50.0'	131° 3.1'	30	-4.60
VEC81B-105b	52° 50.0'	131° 3.1'	30	-4.93
VEC81B-106	52° 52.0'	131° 3.1'	30	-1.07
VEC81B-107	52° 54.0'	131° 3.1'	33	-2.21
VEC81B-108	52° 54.0'	131° 0.0'	29	-1.09
VEC81B-109	52° 52.0'	131° 0.0'	34	-1.88
VEC81B-110	52° 50.0'	131° 0.0'	32	-1.99
VEC81B-111	52° 48.0'	131° 0.0'	33	-1.71
VEC81B-112	53° 2.0'	130° 46.4'	104	3.51
VEC81B-113	53° 4.1'	130° 46.5'	120	2.65
VEC81B-114	53° 4.1'	130° 49.9'	88	0.48
VEC81B-115	53° 2.0'	130° 49.7'	76	2.47
VEC81B-116	53° 2.0'	130° 53.1'	57	2.40
VEC81B-117	53° 4.1'	130° 53.0'	65	2.02
VEC81B-118	53° 4.0'	130° 56.5'	50	2.43
VEC81B-119	53° 2.0'	130° 56.5'	29	-1.94
VEC81B-120	53° 2.1'	131° 0.1'	37	1.78
VEC81B-121	53° 4.0'	131° 0.1'	50	2.42
VEC81B-122	53° 4.0'	131° 3.1'	49	2.29
VEC81B-123	53° 2.0'	131° 3.1'	36	0.66
VEC81B-124	53° 0.0'	131° 3.1'	32	1.39
VEC81B-125a	52° 58.0'	131° 3.1'	37	0.81
VEC81B-125b	52° 58.0'	131° 3.1'	37	-2.57
VEC81B-126	52° 56.0'	131° 3.1'	35	-0.57
VEC81B-127	52° 52.0'	131° 13.0'	28	-4.66
VEC81B-128	52° 54.0'	131° 13.0'	30	-2.62
VEC81B-129	52° 56.0'	131° 13.0'	29	-2.80
VEC81B-130	52° 58.0'	131° 13.0'	38	-2.03
VEC81B-131	53° 0.0'	131° 13.0'	28	-3.31
VEC81B-132	53° 2.0'	131° 13.0'	34	0.02
VEC81B-133	53° 4.0'	131° 13.0'	36	0.12
VEC81B-134	53° 4.0'	131° 16.0'	36	-0.67
VEC81B-135	53° 2.0'	131° 16.0'	29	-3.47
VEC81B-136	53° 0.0'	131° 16.0'	35	-1.66
VEC81B-137b	52° 58.0'	131° 16.2'	29	-3.93
VEC81B-138a	52° 56.0'	131° 16.2'	39	-1.93
VEC81B-138b	52° 56.0'	131° 16.2'	39	-3.88
VEC81B-139	52° 54.0'	131° 16.1'	54	-2.72

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
VEC81B-93	84.7	14.7	0.6	39.5	
VEC81B-94b	98.9	1.0	0.1		
VEC81B-95	65.7	32.8	1.5	29.5	
VEC81B-96	31.9	65.4	2.7	42.0	
VEC81B-97	35.8	60.2	4.0	22.0	
VEC81B-98	48.5	49.0	2.5	4.5	
VEC81B-99	10.6	86.6	2.8	3.8	
VEC81B-100	0.0	97.6	2.4	<2.0	
VEC81B-101	83.3	15.6	1.1	5.0	
VEC81B-102	6.3	83.3	10.4	6.5	
VEC81B-103	0.0	81.5	18.5	<2.0	
VEC81B-104	67.6	31.7	0.7	13.0	
VEC81B-105a	97.1	2.7	0.2		
VEC81B-105b	92.2	7.5	0.3	45.5	
VEC81B-106	54.0	45.1	0.9	50.0	
VEC81B-107	63.1	36.0	0.9	39.0	50
VEC81B-108	51.8	47.4	0.8	43.0	
VEC81B-109	81.9	17.5	0.6	36.0	
VEC81B-110	76.6	22.1	1.3	60.5	15
VEC81B-111	64.9	34.3	0.8	33.5	
VEC81B-112	0.0	88.9	11.1	3.0	
VEC81B-113	0.0	89.1	10.9	<2.0	
VEC81B-114	29.0	64.5	6.5	5.0	
VEC81B-115	0.0	91.2	8.8	2.5	
VEC81B-116	0.0	97.7	2.3	19.5	
VEC81B-117	5.5	90.8	3.7	7.5	
VEC81B-118	0.0	98.2	1.8	16.5	
VEC81B-119	72.1	27.2	0.7	19.0	
VEC81B-120	1.1	97.6	1.3	22.0	
VEC81B-121	0.0	97.8	2.2	10.0	
VEC81B-122	0.0	98.3	1.7	23.5	
VEC81B-123	15.3	83.6	1.1	27.0	
VEC81B-124	0.3	98.7	1.0	18.5	
VEC81B-125a	10.2	88.7	1.1	35.0	
VEC81B-125b	76.6	21.6	1.8	52.5	
VEC81B-126	41.7	57.4	0.9	40.0	
VEC81B-127	92.1	7.6	0.3	49.5	
VEC81B-128	77.0	21.6	1.4	19.5	
VEC81B-129	81.3	18.1	0.6	38.5	
VEC81B-130	71.6	27.2	1.2	51.5	
VEC81B-131	88.2	10.8	1.0	48.0	
VEC81B-132	33.5	64.3	2.2	73.0	80
VEC81B-133	26.6	71.6	1.8	72.0	90
VEC81B-134	45.2	51.5	3.3	63.0	30
VEC81B-135	97.9	1.8	0.3	40.5	
VEC81B-136	63.6	35.4	1.0	47.0	
VEC81B-137b	88.8	10.5	0.7	66.0	
VEC81B-138a	73.4	25.2	1.4	51.0	
VEC81B-138b	93.9	5.5	0.6	34.0	
VEC81B-139	89.1	8.7	2.2	87.5	90

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
VEC81B-140	52 ° 52.0 '	131 ° 16.2 '	84	2.99
VEC81B-141b	52 ° 44.0 '	131 ° 19.7 '	185	-3.40
VEC81B-142	52 ° 46.1 '	131 ° 19.6 '	155	2.20
VEC81B-143	52 ° 48.0 '	131 ° 19.7 '	95	-1.64
VEC81B-144	52 ° 50.0 '	131 ° 19.7 '	93	0.92
VEC81B-145	52 ° 52.0 '	131 ° 19.7 '	90	0.29
VEC81B-146	52 ° 54.0 '	131 ° 19.7 '	78	2.30
VEC81B-147	52 ° 56.1 '	131 ° 19.7 '	30	-2.36
VEC81B-148b	52 ° 58.2 '	131 ° 19.6 '	30	-0.22
VEC81B-149	53 ° 0.0 '	131 ° 19.0 '	21	-1.11
VEC81B-150	53 ° 2.0 '	131 ° 19.0 '	30	-3.02
VEC81B-151	53 ° 4.1 '	131 ° 19.8 '	32	-3.27
VEC81B-152	53 ° 4.0 '	131 ° 23.0 '	35	-6.17
VEC81B-153	53 ° 2.1 '	131 ° 23.1 '	30	-0.17
VEC81B-154	53 ° 0.0 '	131 ° 23.0 '	24	-4.84
VEC81B-155	52 ° 58.0 '	131 ° 23.0 '	24	
VEC81B-156	52 ° 56.0 '	131 ° 23.0 '	40	-1.55
VEC81B-157	52 ° 54.0 '	131 ° 23.0 '	82	1.96
VEC81B-158	52 ° 52.0 '	131 ° 23.0 '	159	3.62
VEC81B-159	52 ° 50.0 '	131 ° 23.0 '	179	-0.69
VEC81B-160	52 ° 48.0 '	131 ° 23.0 '	155	0.54
VEC81B-161	52 ° 46.0 '	131 ° 23.0 '	152	2.36
VEC81B-162	52 ° 44.0 '	131 ° 23.0 '	205	2.72
VEC81B-163	52 ° 44.0 '	131 ° 26.4 '	145	-0.81
VEC81B-164	52 ° 46.0 '	131 ° 26.4 '	150	0.51
VEC81B-165	52 ° 48.0 '	131 ° 26.4 '	95	2.53
VEC81B-166	52 ° 50.0 '	131 ° 26.4 '	210	-4.45
VEC81B-167	52 ° 52.0 '	131 ° 26.4 '	140	-1.51
VEC81B-168b	52 ° 54.0 '	131 ° 26.4 '	95	1.99
VEC81B-169	52 ° 54.0 '	131 ° 33.0 '	190	-2.89
VEC81B-170	52 ° 54.0 '	131 ° 35.5 '	48	2.57
VEC81B-171	52 ° 56.0 '	131 ° 33.0 '	51	0.10
VEC81B-172	52 ° 56.0 '	131 ° 33.0 '	80	0.85
VEC81B-173a	52 ° 58.0 '	131 ° 33.0 '	48	
VEC81B-173b	52 ° 58.0 '	131 ° 33.0 '	48	-4.41
VEC81B-174	53 ° 0.0 '	131 ° 33.0 '	20	-4.94
VEC81B-175	53 ° 2.2 '	131 ° 32.8 '	33	-0.61
VEC81B-176	53 ° 4.0 '	131 ° 36.0 '	25	-0.16
VEC81B-177	53 ° 4.0 '	131 ° 33.0 '	28	
VEC81B-178	53 ° 4.0 '	131 ° 30.0 '	28	-1.18
VEC81B-179	53 ° 2.1 '	131 ° 30.1 '	22	-2.80
VEC81B-180	53 ° 0.1 '	131 ° 30.0 '	23	-2.12
VEC81B-181	52 ° 58.0 '	131 ° 30.0 '	49	1.11
VEC81B-182	52 ° 56.0 '	131 ° 30.0 '	53	
VEC81B-183	52 ° 56.0 '	131 ° 26.3 '	67	1.55
VEC81B-184	52 ° 58.0 '	131 ° 26.4 '	36	
VEC81B-185	53 ° 0.0 '	131 ° 26.4 '	14	-4.05
VEC81B-186	53 ° 2.1 '	131 ° 26.4 '	16	-3.26
VEC81B-187	53 ° 4.0 '	131 ° 26.4 '	29	-0.93
VEC81B-188	52 ° 59.0 '	130 ° 56.5 '	29	-1.11

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
VEC81B-140	0.0	97.5	2.5	<2.0	
VEC81B-141b	79.9	18.1	2.0	13.0	
VEC81B-142	14.7	74.5	10.8	13.0	
VEC81B-143	60.4	36.2	3.4	36.0	
VEC81B-144	19.2	76.7	4.1	8.0	
VEC81B-145	33.5	60.5	6.0	15.5	
VEC81B-146	0.0	98.7	1.3	<2.0	
VEC81B-147	75.6	22.4	2.0	53.5	
VEC81B-148b	38.2	61.1	0.7	72.0	70
VEC81B-149	52.5	44.1	3.4	74.0	
VEC81B-150	64.9	33.7	1.4	87.5	
VEC81B-151	72.0	26.4	1.6	56.0	
VEC81B-152	99.6	0.3	0.1		
VEC81B-153	38.2	59.7	2.1	83.5	80
VEC81B-154	90.2	9.6	0.2	57.5	
VEC81B-155					
VEC81B-156	69.3	27.6	3.1	93.5	95
VEC81B-157	9.1	85.9	5.0	17.0	
VEC81B-158	0.0	91.5	8.5	<2.0	
VEC81B-159	53.9	39.6	6.5	12.5	
VEC81B-160	38.4	55.1	6.5	6.5	
VEC81B-161	13.9	77.1	9.0	4.5	
VEC81B-162	2.6	90.3	7.1	4.5	
VEC81B-163	54.9	35.1	10.0	16.0	
VEC81B-164	46.9	37.9	15.2	11.5	
VEC81B-165	14.9	43.2	41.9	52.0	
VEC81B-166	90.7	5.4	3.9	12.5	
VEC81B-167	77.2	18.1	4.7	19.0	
VEC81B-168b	15.9	67.3	16.8	62.0	
VEC81B-169	79.4	12.6	8.0	15.5	
VEC81B-170	7.3	74.2	18.5	60.0	
VEC81B-171	40.8	52.2	7.0	94.0	95
VEC81B-172	33.4	59.7	6.9	33.0	
VEC81B-173a				92.0	50
VEC81B-173b	85.4	12.9	1.7		
VEC81B-174	84.2	15.2	0.6	82.0	
VEC81B-175	52.9	44.2	2.9	98.0	99
VEC81B-176	40.9	56.7	2.4	97.5	95
VEC81B-177				87.5	
VEC81B-178	49.4	48.7	1.9	95.5	70
VEC81B-179	72.5	25.2	2.3	93.5	50
VEC81B-180	58.1	40.7	1.2	52.0	
VEC81B-181	15.1	81.8	3.1	50.0	
VEC81B-182				86.5	
VEC81B-183	7.8	87.1	5.1	75.5	
VEC81B-184				50.5	
VEC81B-185	95.1	4.3	0.6	47.0	
VEC81B-186	81.3	18.4	0.3	45.0	
VEC81B-187	50.1	49.0	0.9	61.0	
VEC81B-188	55.0	44.6	0.4	8.0	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
VEC81B-189	52 ° 52.0 '	130 ° 56.5 '	35	0.57
VEC81B-190	52 ° 50.0 '	130 ° 56.5 '	40	-1.14
VEC81B-191	52 ° 48.0 '	130 ° 56.5 '	45	-1.96
VEC81B-192	52 ° 48.0 '	130 ° 53.2 '	56	1.36
VEC81B-193	52 ° 50.0 '	130 ° 53.1 '	49	1.00
VEC81B-194a	52 ° 52.1 '	130 ° 53.1 '	40	-0.31
VEC81B-194b	52 ° 52.1 '	130 ° 53.1 '	40	-3.66
VEC81B-195	52 ° 54.0 '	130 ° 53.1 '	38	1.70
VEC81B-196	52 ° 54.0 '	130 ° 49.8 '	42	0.51
VEC81B-197	52 ° 52.1 '	130 ° 49.7 '	50	1.39
VEC81B-198	52 ° 50.1 '	130 ° 49.8 '	65	1.17
VEC81B-199	52 ° 48.0 '	130 ° 49.7 '	72	1.67
VEC81B-200	52 ° 50.0 '	130 ° 46.5 '	70	2.61
VEC81B-201	52 ° 52.0 '	130 ° 46.5 '	52	1.37
VEC81B-202	52 ° 54.0 '	130 ° 46.5 '	50	-2.13
VEC81B-203	52 ° 52.0 '	130 ° 43.1 '	72	-0.97
VEC81B-204	52 ° 52.0 '	130 ° 39.8 '	86	1.72
VEC81B-205	52 ° 52.0 '	130 ° 36.5 '	109	3.62
VEC81B-206	52 ° 52.0 '	130 ° 33.1 '	119	2.74
VEC81B-207	52 ° 50.0 '	130 ° 33.1 '	127	2.83
VEC81B-208	52 ° 50.0 '	130 ° 36.5 '	119	3.69
VEC81B-209	52 ° 50.0 '	130 ° 39.8 '	102	
VEC81B-210	52 ° 50.0 '	130 ° 43.1 '	85	2.15
VEC81B-211	52 ° 59.0 '	131 ° 0.0 '	30	-1.47
VEC81B-212a	52 ° 59.0 '	130 ° 58.0 '	34	1.35
VEC81B-212b	52 ° 59.0 '	130 ° 58.0 '	34	0.43
VEC81B-213	52 ° 59.0 '	130 ° 55.5 '	29	-1.49
VEC81B-214	52 ° 57.0 '	130 ° 55.7 '	33	-1.90
VEC81B-215	52 ° 57.0 '	130 ° 58.1 '	32	-1.12
VEC81B-216	52 ° 57.0 '	131 ° 0.0 '	34	1.36
VEC81B-217	52 ° 55.0 '	131 ° 0.0 '	33	-0.47
VEC81B-218	52 ° 55.0 '	130 ° 58.0 '	29	0.14
VEC81B-219	52 ° 54.9 '	130 ° 55.5 '	35	-1.44
VEC81B-220	52 ° 41.8 '	131 ° 19.4 '	108	-3.85
VEC81B-221	52 ° 42.0 '	131 ° 23.0 '	100	0.20
VEC81B-222	52 ° 40.0 '	131 ° 23.0 '	95	1.44
VEC81B-223	52 ° 40.0 '	131 ° 19.4 '	120	2.39
VEC81B-224	52 ° 38.0 '	131 ° 23.2 '	81	1.33
VEC81B-225	52 ° 38.0 '	131 ° 19.2 '	132	2.72
VEC81B-226	52 ° 36.0 '	131 ° 19.2 '	128	3.35
PAR83A-4	53 ° 12.4 '	131 ° 2.8 '	46	0.40
PAR83A-5	53 ° 12.4 '	131 ° 2.8 '	46	0.69
PAR83A-6	53 ° 10.5 '	131 ° 14.7 '	35	-1.30
PAR83A-7	53 ° 10.5 '	131 ° 14.7 '	35	-2.88
GBR83A-4	53 ° 50.0 '	131 ° 21.8 '	24	-2.87
GBR83A-5	53 ° 50.0 '	131 ° 11.4 '	26	-1.01
GBR83A-6	53 ° 50.0 '	131 ° 3.4 '	44	0.57
GBR83A-7	53 ° 39.2 '	131 ° 5.6 '	38	-1.95
GBR83A-8	53 ° 25.0 '	131 ° 12.1 '	29	0.71
GBR83A-9	53 ° 25.0 '	131 ° 18.8 '	26	1.19

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
VEC81B-189	19.8	79.3	0.9	29.0	
VEC81B-190	60.2	38.9	0.9	27.5	
VEC81B-191	61.8	37.3	0.9	30.5	
VEC81B-192	2.2	96.7	1.1	7.0	
VEC81B-193	6.7	92.4	0.9	7.5	40
VEC81B-194a	24.4	73.8	1.8	36.0	
VEC81B-194b	80.4	18.8	0.8	39.0	
VEC81B-195	1.5	96.5	2.0	19.5	
VEC81B-196	21.6	77.4	1.0	14.5	
VEC81B-197	11.9	77.5	10.6	23.0	
VEC81B-198	4.1	95.0	0.9	2.0	
VEC81B-199	0.1	99.0	0.9	<2.0	
VEC81B-200	0.0	98.8	1.2	<2.0	
VEC81B-201	8.0	90.1	1.9	20.0	
VEC81B-202	74.5	24.5	1.0	49.0	20
VEC81B-203	47.2	49.5	3.3	27.5	
VEC81B-204	13.1	83.6	3.3	5.0	
VEC81B-205	0.0	85.9	14.1	<2.0	
VEC81B-206	0.0	84.0	16.0	<2.0	
VEC81B-207	0.0	80.4	19.6	<2.0	
VEC81B-208	0.0	75.2	24.8		
VEC81B-209					
VEC81B-210	0.5	97.9	1.6	<2.0	
VEC81B-211	68.2	31.2	0.6	20.0	
VEC81B-212a	9.3	89.5	1.2	21.0	
VEC81B-212b	24.0	75.2	0.8	26.5	
VEC81B-213	64.6	32.9	2.5	53.5	
VEC81B-214	64.7	34.3	1.0	10.0	
VEC81B-215	71.2	28.1	0.7	19.0	
VEC81B-216	5.2	93.7	1.1	31.0	
VEC81B-217	41.5	56.1	2.4	33.5	40
VEC81B-218	24.4	74.7	0.9	21.0	
VEC81B-219	63.7	35.8	0.5	17.5	
VEC81B-220	93.3	5.7	1.0	15.0	
VEC81B-221	47.3	33.8	18.9	40.0	
VEC81B-222	18.5	72.0	9.5	68.5	
VEC81B-223	0.0	94.7	5.3	3.5	
VEC81B-224	28.8	53.6	17.6	25.5	
VEC81B-225	0.0	92.3	7.7	4.0	
VEC81B-226	0.0	91.6	8.4	<2.0	
PAR83A-4	23.7	75.7	0.6		
PAR83A-5	15.4	83.6	1.0		
PAR83A-6	62.0	37.4	0.6		
PAR83A-7	89.0	10.5	0.5		
GBR83A-4	80.0	18.8	1.2		
GBR83A-5	55.6	42.7	1.7		
GBR83A-6	39.0	46.2	14.8		
GBR83A-7	67.5	30.9	1.6		
GBR83A-8	13.7	85.6	0.7	12.0	40
GBR83A-9	2.5	96.7	0.8	19.0	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR83A-10	53° 25.0'	131° 25.5'	24	-2.63
GBR83A-11	53° 25.0'	131° 32.5'	22	1.26
GBR83A-12	53° 25.0'	131° 39.3'	27	1.96
GBR83A-13	53° 20.0'	131° 32.8'	38	2.35
GBR83A-14a	53° 20.0'	131° 25.8'	29	-4.32
GBR83A-14b	53° 20.0'	131° 25.8'	29	0.83
GBR83A-15	53° 20.0'	131° 19.0'	29	-0.30
GBR83A-16	53° 20.0'	131° 12.2'	31	0.83
GBR83A-17	53° 20.0'	131° 5.6'	51	-1.31
GBR83A-18	53° 15.0'	131° 7.1'	40	-0.42
GBR83A-19	53° 15.0'	131° 13.6'	40	-0.82
GBR83A-20	53° 15.0'	131° 20.7'	35	0.77
GBR83A-21	53° 15.0'	131° 27.5'	26	0.06
GBR83A-22a	53° 10.0'	131° 33.0'	20	0.51
GBR83A-22b	53° 10.0'	131° 33.0'	20	-2.41
GBR83A-23	53° 10.0'	131° 26.0'	27	-2.08
GBR83A-24	53° 10.0'	131° 19.3'	27	-0.59
GBR83A-25	53° 10.0'	131° 12.1'	37	0.68
GBR83A-26	53° 10.0'	131° 5.0'	42	-1.18
GBR83A-27	53° 5.0'	131° 7.0'	37	1.81
GBR83A-28	53° 5.0'	131° 14.2'	31	1.43
GBR83A-29	53° 5.0'	131° 21.0'	26	0.07
GBR83A-30	53° 5.0'	131° 28.0'	26	0.29
GBR83A-31	53° 0.0'	131° 20.1'	20	-4.07
GBR83A-32	53° 0.0'	131° 15.0'	24	-1.98
GBR83A-33	53° 0.0'	131° 10.0'	27	-1.32
GBR83A-34	53° 0.0'	131° 5.0'	24	-0.68
GBR83A-35	53° 0.0'	131° 0.0'	29	1.42
GBR83A-36	53° 0.0'	130° 55.0'	37	0.22
GBR83A-37	53° 0.0'	130° 51.0'	64	2.59
GBR83B-10	52° 57.0'	130° 39.4'	70	1.02
GBR83B-11	52° 57.4'	130° 38.8'	73	0.40
GBR83B-12	52° 57.7'	130° 38.0'	90	0.86
GBR83B-13	52° 52.9'	130° 37.6'	117	0.35
GBR83B-14	52° 58.7'	130° 36.7'	121	3.74
GBR83B-15	52° 59.5'	130° 35.4'	95	2.24
GBR83B-16	52° 0.0'	130° 34.9'	91	1.34
GBR83B-17	53° 0.3'	130° 34.3'	91	-0.09
GBR83B-18	53° 1.0'	130° 32.9'	91	0.99
GBR83B-19	53° 1.4'	130° 32.2'	112	1.33
GBR84A-65	53° 42.1'	130° 30.0'	70	4.01
GBR84A-66	53° 42.1'	130° 33.2'	57	3.93
GBR84A-67	53° 42.1'	130° 36.5'	66	3.37
GBR84A-68	53° 42.1'	130° 39.6'	130	3.56
GBR84A-69	53° 42.1'	130° 43.0'	135	3.54
GBR84A-70	53° 42.1'	130° 46.5'	113	2.61
GBR84A-71	53° 42.1'	130° 49.9'	59	2.17
GBR84A-72	53° 42.1'	130° 53.2'	49	1.38
GBR84A-73	53° 42.1'	130° 56.5'	44	0.26
GBR84A-74	53° 42.1'	131° 0.0'	38	-0.65

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR83A-10	65.2	34.2	0.6	17.0	3
GBR83A-11	2.0	96.6	1.4	21.5	
GBR83A-12	1.1	94.7	4.2	11.5	70
GBR83A-13	0.0	96.0	4.0	54.5	
GBR83A-14a	84.0	15.2	0.8	33.0	5
GBR83A-14b	13.9	84.6	1.5	44.0	50
GBR83A-15	38.6	60.6	0.8	40.0	
GBR83A-16	17.9	80.2	1.9	6.0	15
GBR83A-17	52.3	44.9	2.8	29.5	
GBR83A-18	37.9	61.4	0.7	16.0	
GBR83A-19	45.5	53.0	1.5	38.0	27
GBR83A-20	12.6	85.9	1.5	65.5	
GBR83A-21	25.2	74.0	0.8	38.0	100
GBR83A-22a	20.4	76.6	3.0	77.5	75
GBR83A-22b	78.7	19.9	1.4	81.0	15
GBR83A-23	62.7	36.4	0.9	62.5	15
GBR83A-24	37.4	61.7	0.9	66.5	
GBR83A-25	12.8	86.0	1.2	65.0	
GBR83A-26	63.7	35.6	0.7	12.0	1
GBR83A-27	0.6	98.6	0.8	20.5	
GBR83A-28	6.2	88.3	5.5	59.0	
GBR83A-29	30.3	67.7	2.0	88.5	
GBR83A-30	25.7	72.2	2.1	93.0	
GBR83A-31	87.3	11.9	0.8	83.5	
GBR83A-32	60.9	38.2	0.9		
GBR83A-33	59.3	40.0	0.7	35.0	
GBR83A-34	43.3	56.1	0.6	27.5	
GBR83A-35	3.5	95.5	1.0	30.0	
GBR83A-36	28.1	71.2	0.7	23.0	
GBR83A-37	0.0	98.1	1.9	7.0	
GBR83B-10	3.2	95.9	0.9		
GBR83B-11	24.4	73.7	1.9		
GBR83B-12	18.8	79.6	1.6		
GBR83B-13	31.1	66.7	2.2		
GBR83B-14	0.0	80.2	19.8		
GBR83B-15	4.8	86.3	8.9		
GBR83B-16	14.3	77.2	8.5		
GBR83B-17	40.0	54.6	5.4		
GBR83B-18	3.2	95.6	1.2		
GBR83B-19	2.9	96.1	1.0		
GBR84A-65	0.0	75.9	24.1	16.0	
GBR84A-66	0.0	81.7	18.3	35.0	
GBR84A-67	0.0	91.2	8.8	34.0	
GBR84A-68	0.0	87.3	12.7	<2.0	
GBR84A-69	0.0	86.8	13.2	<2.0	
GBR84A-70	0.0	97.8	2.2	<2.0	
GBR84A-71	0.1	97.9	2.0	<2.0	
GBR84A-72	0.0	99.1	0.9	6.0	
GBR84A-73	32.4	66.6	1.0	12.0	
GBR84A-74	43.7	53.2	3.1	79.5	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR84A-75	53 ° 42.1 '	131 ° 3.2 '	40	1.73
GBR84A-76	53 ° 42.1 '	131 ° 6.2 '	51	1.58
GBR84A-77	53 ° 42.1 '	131 ° 9.6 '	40	1.57
GBR84A-78	53 ° 42.1 '	131 ° 12.9 '	44	0.63
GBR84A-79	53 ° 42.1 '	131 ° 16.4 '	48	2.59
GBR84A-80	53 ° 40.0 '	130 ° 43.0 '	141	3.25
GBR84A-81	53 ° 40.0 '	130 ° 39.8 '	117	3.20
GBR84A-83	53 ° 50.0 '	130 ° 56.5 '	84	1.81
GBR84A-84	53 ° 48.1 '	130 ° 56.5 '	73	2.23
GBR84A-85	53 ° 46.0 '	130 ° 56.5 '	62	1.89
GBR84A-86	53 ° 44.0 '	130 ° 56.5 '	59	1.70
GBR84A-87	53 ° 40.0 '	130 ° 56.5 '	48	-2.87
GBR84A-88	53 ° 38.2 '	130 ° 56.5 '	51	0.78
GBR84A-89	53 ° 36.2 '	130 ° 56.5 '	59	-3.82
GBR84A-90	53 ° 34.0 '	130 ° 56.5 '	59	-0.18
GBR84A-91	53 ° 40.0 '	131 ° 13.0 '	35	0.05
GBR84A-92	53 ° 40.0 '	131 ° 16.5 '	24	1.56
GBR84A-93	53 ° 40.0 '	131 ° 20.0 '	20	1.96
GBR84A-94	53 ° 40.0 '	131 ° 23.0 '	18	1.96
GBR84A-95	53 ° 40.0 '	131 ° 26.5 '	20	1.99
GBR84A-96	53 ° 38.0 '	131 ° 30.0 '	22	1.39
GBR84A-97	53 ° 38.0 '	131 ° 26.9 '	20	2.19
GBR84A-98	53 ° 38.0 '	131 ° 23.3 '	20	0.82
GBR84A-99	53 ° 38.0 '	131 ° 20.0 '	18	1.56
GBR84A-100	53 ° 38.0 '	131 ° 16.5 '	20	1.29
GBR84A-101	53 ° 38.0 '	131 ° 13.0 '	24	1.20
GBR84A-102	53 ° 36.0 '	131 ° 13.0 '	20	1.35
GBR84A-103	53 ° 36.0 '	131 ° 16.5 '	26	0.86
GBR84A-104	53 ° 36.0 '	131 ° 19.8 '	20	1.88
GBR84A-105	53 ° 14.0 '	130 ° 53.1 '	119	2.42
GBR84A-106	53 ° 14.0 '	130 ° 49.9 '	121	1.62
GBR84A-107	53 ° 14.0 '	130 ° 46.2 '	155	4.06
GBR84A-108	53 ° 14.0 '	130 ° 43.3 '	170	4.86
GBR84A-109	53 ° 15.8 '	130 ° 43.3 '	188	5.71
GBR84A-110	53 ° 17.8 '	130 ° 43.3 '	183	7.40
GBR84A-111	53 ° 17.8 '	130 ° 46.5 '	154	4.88
GBR84A-112	53 ° 17.8 '	130 ° 49.8 '	148	2.88
GBR84A-113	53 ° 17.8 '	130 ° 53.2 '	128	2.56
GBR84A-114	53 ° 17.8 '	130 ° 56.5 '	91	1.44
GBR84A-115	53 ° 17.8 '	131 ° 0.0 '	79	1.14
GBR84A-116	53 ° 17.8 '	131 ° 3.0 '	64	2.00
GBR84A-117	53 ° 17.8 '	131 ° 6.5 '	50	2.12
GBR84A-118	53 ° 6.0 '	130 ° 39.8 '	137	3.38
GBR84A-119	53 ° 6.0 '	130 ° 43.2 '	128	3.41
GBR84A-120	53 ° 6.0 '	130 ° 46.6 '	126	3.64
GBR84A-121	53 ° 6.0 '	130 ° 49.9 '	123	3.50
GBR84A-122	53 ° 6.0 '	130 ° 53.0 '	90	-2.22
GBR84A-123	53 ° 6.0 '	130 ° 56.5 '	66	2.30
GBR84A-124	53 ° 6.0 '	131 ° 0.0 '	50	2.60
GBR84A-125	53 ° 6.0 '	131 ° 3.1 '	46	-1.85

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR84A-75	5.7	92.1	2.2	22.5	
GBR84A-76	0.0	96.0	4.0	14.0	
GBR84A-77	0.3	98.4	1.3	4.5	
GBR84A-78	21.3	76.4	2.3	10.0	
GBR84A-79	0.0	95.1	4.9	6.5	
GBR84A-80	0.0	91.9	8.1	3.0	
GBR84A-81	0.0	93.0	7.0	2.0	
GBR84A-83	0.0	98.6	1.4	2.0	
GBR84A-84	0.0	98.7	1.3	<2.0	
GBR84A-85	0.0	98.7	1.3	2.0	
GBR84A-86	2.0	96.2	1.8	5.5	
GBR84A-87	64.1	35.4	0.5	1.5	
GBR84A-88	10.7	88.6	0.7	<2.0	
GBR84A-89	86.3	13.0	0.7	12.0	25
GBR84A-90	36.7	61.9	1.4	5.0	
GBR84A-91	34.8	64.2	1.0	12.0	
GBR84A-92	7.9	90.2	1.9	6.0	
GBR84A-93	0.0	98.8	1.2	3.5	
GBR84A-94	0.0	99.0	1.0	4.0	
GBR84A-95	2.8	95.7	1.5	10.0	
GBR84A-96	0.6	98.4	1.0	11.0	
GBR84A-97	0.0	98.5	1.5	3.0	
GBR84A-98	12.1	87.0	0.9	10.5	
GBR84A-99	0.0	99.0	1.0	7.0	
GBR84A-100	3.3	95.6	1.1	10.5	
GBR84A-101	3.0	96.0	1.0	7.0	
GBR84A-102	0.3	98.5	1.2	10.5	
GBR84A-103	12.9	86.1	1.0	14.5	
GBR84A-104	0.0	98.8	1.2	4.0	
GBR84A-105	0.0	96.3	3.7	<2.0	
GBR84A-106	3.0	92.6	4.4	<2.0	
GBR84A-107	0.0	62.4	37.6	<2.0	
GBR84A-108	0.0	49.3	50.7	<2.0	
GBR84A-109	0.0	42.3	57.7	<2.0	
GBR84A-110	0.0	18.0	82.0	<2.0	
GBR84A-111	0.0	56.4	43.6	4.5	
GBR84A-112	0.0	84.2	15.8	5.0	
GBR84A-113	0.0	95.9	4.1	<2.0	
GBR84A-114	0.0	98.7	1.3	<2.0	
GBR84A-115	12.8	85.6	1.6	<2.0	
GBR84A-116	0.0	98.8	1.2	<2.0	
GBR84A-117	0.0	96.8	3.2	<2.0	
GBR84A-118	0.0	81.9	18.1	<2.0	
GBR84A-119	0.0	89.0	11.0	<2.0	
GBR84A-120	0.0	83.9	16.1	<2.0	
GBR84A-121	0.0	83.9	16.1	<2.0	
GBR84A-122	73.3	24.0	2.7	4.5	
GBR84A-123	0.0	98.4	1.6	<2.0	
GBR84A-124	0.0	98.0	2.0	10.0	
GBR84A-125	53.3	45.5	1.2	34.5	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR84A-126	53 ° 6.0 '	131 ° 6.5 '	38	-2.53
GBR84A-127	53 ° 6.0 '	131 ° 9.8 '	33	2.82
GBR84A-128	53 ° 6.0 '	131 ° 13.0 '	31	0.10
GBR84A-129	53 ° 6.0 '	131 ° 16.5 '	31	0.16
GBR84A-130	53 ° 6.0 '	131 ° 19.9 '	31	-1.24
GBR84A-131	53 ° 6.0 '	131 ° 23.3 '	27	-1.17
GBR84A-132	53 ° 6.0 '	131 ° 26.6 '	29	-4.89
GBR84A-133	53 ° 6.0 '	131 ° 30.1 '	29	-0.81
GBR84A-134	53 ° 6.0 '	131 ° 33.1 '	20	-1.45
GBR84A-167	53 ° 6.0 '	130 ° 36.5 '	154	4.13
GBR84A-168	53 ° 6.0 '	130 ° 33.2 '	168	3.84
GBR84A-169	53 ° 6.0 '	130 ° 30.0 '	176	7.05
GBR84A-174	53 ° 8.0 '	130 ° 30.0 '	203	3.98
GBR84A-175	53 ° 8.0 '	130 ° 33.0 '	177	6.84
GBR84A-176	53 ° 8.0 '	130 ° 36.5 '	166	6.49
GBR84A-177	53 ° 8.0 '	130 ° 39.8 '	154	4.48
GBR84A-178	53 ° 8.0 '	130 ° 43.0 '	141	4.04
GBR84A-179	53 ° 8.0 '	130 ° 46.6 '	126	-0.34
GBR84A-180	53 ° 8.0 '	130 ° 49.9 '	119	0.20
GBR84A-181	53 ° 8.0 '	130 ° 53.2 '	99	-3.01
GBR84A-182	52 ° 32.0 '	130 ° 56.8 '	135	4.54
GBR84A-183	52 ° 32.0 '	130 ° 53.2 '	91	-2.48
GBR84A-184	52 ° 32.0 '	130 ° 50.0 '	132	2.70
GBR84A-185	52 ° 32.0 '	130 ° 46.6 '	132	1.67
GBR84A-186	52 ° 32.0 '	130 ° 43.2 '	128	3.01
GBR84A-187	52 ° 32.0 '	130 ° 39.8 '	117	1.56
GBR84A-188	52 ° 32.0 '	130 ° 36.5 '	117	0.47
GBR84A-189	52 ° 32.0 '	130 ° 33.0 '	146	2.65
GBR84A-190	52 ° 34.2 '	130 ° 30.0 '	163	2.65
GBR84A-191	52 ° 36.3 '	130 ° 30.0 '	176	3.31
GBR84A-192	52 ° 38.2 '	130 ° 30.0 '	170	4.27
GBR84A-193	52 ° 40.2 '	130 ° 30.0 '	146	1.38
GBR84A-194	52 ° 44.0 '	130 ° 30.0 '	146	1.32
GBR84A-195	52 ° 46.0 '	130 ° 30.0 '	145	1.78
GBR84A-196	52 ° 48.0 '	130 ° 30.0 '	148	3.89
GBR84A-197	52 ° 50.0 '	130 ° 30.0 '	134	-1.17
GBR84A-198	52 ° 50.0 '	130 ° 30.0 '	134	2.94
GBR84A-204	52 ° 34.0 '	130 ° 36.5 '	146	3.31
GBR84A-205	52 ° 30.0 '	130 ° 36.5 '	104	-2.79
PAR84A-7	53 ° 45.1 '	131 ° 36.6 '	17	1.83
GBR85A-22	53 ° 32.8 '	131 ° 19.5 '	25	1.61
GBR85A-23	53 ° 32.0 '	131 ° 19.7 '	26	1.28
GBR85A-24	53 ° 31.0 '	131 ° 19.7 '	27	1.21
GBR85A-25	53 ° 30.0 '	131 ° 19.8 '	29	2.03
GBR85A-26	53 ° 30.0 '	131 ° 18.2 '	31	1.97
GBR85A-27	53 ° 30.0 '	131 ° 16.4 '	24	-2.36
GBR85A-28	53 ° 30.0 '	131 ° 14.8 '	26	-1.38
GBR85A-29	53 ° 31.0 '	131 ° 14.8 '	31	1.15
GBR85A-30	53 ° 32.2 '	131 ° 14.7 '	26	0.24
GBR85A-31	53 ° 33.0 '	131 ° 14.3 '	29	0.63

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR84A-126	75.7	21.8	2.5	45.5	
GBR84A-127	1.4	81.6	17.0	55.0	
GBR84A-128	30.9	67.4	1.7	79.5	
GBR84A-129	22.6	76.0	1.4	42.5	
GBR84A-130	72.8	25.1	2.1	96.0	
GBR84A-131	68.1	29.4	2.5	91.5	
GBR84A-132	90.3	9.2	0.5	83.0	
GBR84A-133	47.8	48.5	3.7	82.0	
GBR84A-134	62.5	33.9	3.6	84.0	
GBR84A-167	0.0	69.3	30.7	<2.0	
GBR84A-168	0.0	74.3	25.7	<2.0	
GBR84A-169	0.0	14.2	85.8	<2.0	
GBR84A-174	12.3	49.2	38.5	<2.0	
GBR84A-175	0.0	18.5	81.5	13.0	
GBR84A-176	0.0	19.5	80.5	14.5	
GBR84A-177	0.0	49.4	50.6	<2.0	
GBR84A-178	0.0	70.5	29.5	<2.0	
GBR84A-179	45.3	48.2	6.5	<2.0	
GBR84A-180	34.4	56.9	8.7	<2.0	
GBR84A-181	84.1	13.3	2.6	14.0	
GBR84A-182	4.8	46.9	48.3	7.5	
GBR84A-183	85.4	11.0	3.6		
GBR84A-184	0.0	96.6	3.4	<2.0	
GBR84A-185	11.0	86.7	2.3	<2.0	
GBR84A-186	0.0	86.8	13.2	<2.0	
GBR84A-187	0.2	96.9	2.9	<2.0	
GBR84A-188	27.9	67.7	4.4	4.0	1
GBR84A-189	0.0	85.3	14.7	<2.0	
GBR84A-190	0.0	86.3	13.7	<2.0	
GBR84A-191	0.0	81.9	18.1	4.5	
GBR84A-192	0.0	64.4	35.6	7.0	
GBR84A-193	23.8	59.7	16.5	6.5	
GBR84A-194	30.4	47.9	21.7	11.5	
GBR84A-195	8.4	79.6	12.0	<2.0	
GBR84A-196	0.0	71.1	28.9	<2.0	
GBR84A-197	55.5	37.9	6.6	9.0	
GBR84A-198	6.0	70.4	23.6	<2.0	
GBR84A-204	0.0	81.7	18.3	<2.0	
GBR84A-205	79.0	19.5	1.5	33.0	
PAR84A-7	1.7	97.0	1.3	10.0	
GBR85A-22	1.1	98.0	0.9	8.5	
GBR85A-23	3.2	95.7	1.1	18.0	
GBR85A-24	4.1	94.9	1.0	15.5	
GBR85A-25	1.8	97.1	1.1	12.0	25
GBR85A-26	0.9	98.2	0.9	3.0	
GBR85A-27	74.9	24.5	0.6	14.5	
GBR85A-28	65.7	33.6	0.7	27.5	5
GBR85A-29	3.8	95.4	0.8	12.0	
GBR85A-30	25.6	73.4	1.0	12.0	
GBR85A-31	16.6	82.2	1.2	12.5	80

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (m)	MEAN SIZE ø
GBR85A-32	53 ° 33.0 '	131 ° 11.2 '	29	0.96
GBR85A-33	53 ° 33.0 '	131 ° 17.9 '	27	1.44
GBR85A-34	53 ° 32.0 '	131 ° 18.6 '	31	1.69
GBR85A-35	53 ° 31.0 '	131 ° 18.0 '	33	2.00
GBR85A-36	53 ° 31.0 '	131 ° 16.5 '	29	1.65
GBR85A-37	53 ° 32.0 '	131 ° 16.5 '	29	0.74
GBR85A-38	53 ° 9.5 '	130 ° 45.0 '	146	3.99
GBR85A-39	53 ° 9.5 '	130 ° 46.7 '	131	1.67
GBR85A-40	53 ° 9.5 '	130 ° 48.5 '	128	2.68
GBR85A-41	53 ° 9.5 '	130 ° 50.0 '	119	-1.43
GBR85A-42	53 ° 10.5 '	130 ° 50.0 '	140	-0.84
GBR85A-43	53 ° 10.5 '	130 ° 48.5 '	144	2.49
GBR85A-44	53 ° 10.5 '	130 ° 46.7 '	131	3.08
GBR85A-45	53 ° 10.5 '	130 ° 45.0 '	120	2.79
GBR85A-46	53 ° 11.5 '	130 ° 45.0 '	151	3.92
GBR85A-47	53 ° 11.5 '	130 ° 46.7 '	144	3.31
GBR85A-48	53 ° 11.5 '	130 ° 48.5 '	128	1.88
GBR85A-49	53 ° 11.5 '	130 ° 50.0 '	124	1.35
GBR85A-50	53 ° 12.5 '	130 ° 50.0 '	128	1.58
GBR85A-51	53 ° 12.5 '	130 ° 48.5 '	128	1.56
GBR85A-52	53 ° 12.5 '	130 ° 46.7 '	130	3.38
GBR85A-53	53 ° 12.5 '	130 ° 50.0 '	161	4.40

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
GBR85A-32	9.8	89.3	0.9	18.0	
GBR85A-33	2.3	96.7	1.0	13.5	
GBR85A-34	0.0	99.2	0.8	7.5	
GBR85A-35	0.0	99.2	0.8	3.0	
GBR85A-36	0.8	98.2	1.0	4.5	
GBR85A-37	5.9	93.3	0.8		
GBR85A-38	0.0	71.9	28.1	4.5	
GBR85A-39	7.3	85.1	7.6	3.0	
GBR85A-40	0.0	88.6	11.4	<2.0	
GBR85A-41	57.3	35.8	6.9	6.5	
GBR85A-42	54.7	33.1	12.2	5.5	
GBR85A-43	0.0	91.1	8.9		
GBR85A-44	0.0	85.9	14.1	2.5	
GBR85A-45	0.0	87.8	12.2	<2.0	
GBR85A-46	0.0	70.4	29.6	2.5	
GBR85A-47	0.0	84.2	15.8	<2.0	
GBR85A-48	5.1	87.9	7.0	<2.0	
GBR85A-49	17.4	76.7	5.9	2.5	
GBR85A-50	13.6	79.8	6.6		
GBR85A-51	0.7	96.3	3.0	<2.0	
GBR85A-52	0.0	77.6	22.4	4.5	
GBR85A-53	0.0	62.6	37.4	5.0	

2. Cook Bank

See Appendix A.1. for explanation of tables

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (M)
PAR76-90	50 ° 40.0 '	128 ° 24.3 '	60
PAR76-91	50 ° 40.0 '	128 ° 27.5 '	94
PAR76-92	50 ° 40.0 '	128 ° 30.8 '	120
PAR76-93	50 ° 42.1 '	128 ° 30.8 '	104
PAR76-94	50 ° 42.0 '	128 ° 27.6 '	78
PAR76-95	50 ° 42.0 '	128 ° 24.3 '	45
PAR76-96	50 ° 48.2 '	128 ° 27.5 '	66
PAR76-97	50 ° 50.0 '	128 ° 27.6 '	60
PAR76-98	50 ° 52.0 '	128 ° 27.5 '	50
PAR76-99	50 ° 54.0 '	128 ° 27.5 '	70
PAR76-100	50 ° 56.0 '	128 ° 27.5 '	60
PAR76-101	50 ° 58.0 '	128 ° 27.5 '	90
PAR76-102	51 ° 0.0 '	128 ° 27.4 '	86
PAR76-103	51 ° 0.0 '	128 ° 24.3 '	92
PAR76-104	50 ° 58.0 '	128 ° 24.3 '	72
PAR76-105	50 ° 56.0 '	128 ° 24.3 '	53
PAR76-106	50 ° 54.0 '	128 ° 24.3 '	58
PAR76-107	50 ° 52.0 '	128 ° 24.4 '	54
PAR76-108	50 ° 50.0 '	128 ° 24.3 '	44
PAR76-109	50 ° 48.1 '	128 ° 24.3 '	28
PAR76-110	50 ° 50.0 '	128 ° 21.2 '	
PAR76-111	50 ° 50.0 '	128 ° 18.1 '	31
PAR76-112	50 ° 50.1 '	128 ° 15.0 '	30
PAR76-113	50 ° 52.0 '	128 ° 8.6 '	29
PAR76-114	50 ° 52.0 '	128 ° 11.7 '	35
PAR76-115	50 ° 52.0 '	128 ° 14.9 '	41
PAR76-116	50 ° 51.9 '	128 ° 18.0 '	51
PAR76-117	50 ° 54.0 '	128 ° 21.1 '	50
PAR76-118	50 ° 54.0 '	128 ° 21.2 '	77
PAR76-119	50 ° 54.0 '	128 ° 18.0 '	48
PAR76-120	50 ° 54.0 '	128 ° 14.8 '	56
PAR76-121	50 ° 54.0 '	128 ° 11.7 '	48
PAR76-122	50 ° 54.0 '	128 ° 8.6 '	30
PAR76-123	50 ° 54.1 '	128 ° 5.4 '	26
PAR76-124	50 ° 54.0 '	128 ° 2.1 '	27
PAR76-125	50 ° 56.0 '	128 ° 2.2 '	27
PAR76-126	50 ° 56.1 '	128 ° 5.4 '	34
PAR76-127	50 ° 56.0 '	128 ° 8.5 '	43
PAR76-128	50 ° 56.0 '	128 ° 11.7 '	49
PAR76-129	50 ° 56.0 '	128 ° 14.9 '	55
PAR76-130	50 ° 56.0 '	128 ° 18.0 '	86
PAR76-131	50 ° 56.0 '	128 ° 21.1 '	50
PAR76-132	50 ° 58.0 '	128 ° 21.1 '	58
PAR76-133	50 ° 58.1 '	128 ° 18.0 '	74
PAR76-134	50 ° 58.0 '	128 ° 14.9 '	76
PAR76-135	50 ° 58.0 '	128 ° 11.7 '	55
PAR76-136	50 ° 58.0 '	128 ° 8.5 '	55
PAR76-137	50 ° 58.0 '	128 ° 4.4 '	42
PAR76-138	50 ° 58.0 '	128 ° 2.2 '	28
PAR76-139	51 ° 0.0 '	128 ° 2.2 '	117

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
PAR76-90					
PAR76-91	0.3	99.6	0.1		
PAR76-92	0.4	95.7	3.9		
PAR76-93	11.2	88.7	0.1		
PAR76-94	100.0	0.0	0.0		
PAR76-95	94.8	5.2	0.0		
PAR76-96	46.8	53.2	0.0		
PAR76-97	100.0	0.0	0.0		
PAR76-98					
PAR76-99	0.0	99.6	0.4	8.0	
PAR76-100	96.9	3.1	0.0		
PAR76-101	84.4	15.5	0.1		
PAR76-102	99.4	0.6	0.0		
PAR76-103	0.1	99.0	0.9	4.5	
PAR76-104	100.0	0.0	0.0		
PAR76-105					
PAR76-106	0.0	99.9	0.1	12.5	
PAR76-107	100.0	0.0	0.0		
PAR76-108	50.0	48.9	1.1		90
PAR76-109	4.2	94.3	1.5	42.0	
PAR76-110	74.5	25.5	0.0		75
PAR76-111	90.9	9.1	0.0		
PAR76-112					
PAR76-113	14.1	85.9	0.0	2.5	
PAR76-114	82.7	17.3	0.0		
PAR76-115					
PAR76-116	62.9	36.9	0.2	36.0	
PAR76-117	0.8	97.5	1.7	36.0	
PAR76-118	1.8	96.8	1.4	13.0	
PAR76-119	99.5	0.5	0.0		
PAR76-120	99.3	0.7	0.0		
PAR76-121	100.0	0.0	0.0		
PAR76-122	100.0	0.0	0.0		
PAR76-123	96.8	3.1	0.1		50
PAR76-124	0.0	100.0	0.0		
PAR76-125	99.4	0.6	0.0		
PAR76-126	92.6	7.4	0.0		
PAR76-127	0.0	100.0	0.0		
PAR76-128	89.2	10.8	0.0		
PAR76-129	82.2	17.7	0.1		
PAR76-130	1.6	98.1	0.3	9.5	
PAR76-131	99.8	0.2	0.0		
PAR76-132	70.1	29.9	0.0		
PAR76-133	78.4	21.5	0.1	5.5	
PAR76-134	5.5	94.4	0.1	7.0	
PAR76-135	34.0	66.0	0.0	2.0	
PAR76-136	71.0	28.7	0.3		
PAR76-137	92.3	7.7	0.0		
PAR76-138	100.0	0.0	0.0		
PAR76-139	0	84.9	15.1		

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (M)
PAR76-140	51° 0.1'	128° 5.4'	120
PAR76-141	50° 59.9'	128° 8.5'	115
PAR76-142	51° 0.0'	128° 11.3'	102
PAR76-143	51° 0.0'	128° 14.4'	94
PAR76-144	51° 0.0'	128° 18.0'	72
PAR76-145	51° 0.0'	128° 21.2'	80
PAR76-146	51° 0.1'	128° 30.1'	90
PAR76-147	50° 58.0'	128° 30.1'	84
PAR76-148	50° 56.0'	128° 30.1'	75
PAR76-149	50° 54.2'	128° 30.4'	68
PAR76-150	50° 52.2'	128° 30.2'	69
PAR76-151	50° 50.0'	128° 30.4'	65
PAR76-152	50° 48.4'	128° 30.5'	52
PAR76-153	50° 46.2'	128° 30.5'	88
PAN77-2	50° 40.2'	128° 29.7'	95
PAN77-3	50° 40.6'	128° 32.2'	128
PAN77-4	50° 40.0'	128° 36.7'	168
PAN77-74	50° 40.4'	128° 24.8'	55
PAN77-80	50° 44.1'	128° 27.3'	62
PAN77-81	50° 44.0'	128° 30.5'	93
PAN77-82	50° 44.0'	128° 33.7'	92
PAN77-83	50° 44.0'	128° 36.8'	105
PAN77-84	50° 43.9'	128° 40.0'	115
PAN77-85	50° 42.0'	128° 40.1'	145
PAN77-86	50° 42.0'	128° 36.7'	141
PAN77-87	50° 42.0'	128° 33.6'	126
PAN77-88	50° 42.0'	128° 30.5'	110
PAN77-89	50° 42.1'	128° 27.1'	79
PAN77-90	50° 42.0'	128° 24.3'	43
PAN77-104	50° 44.3'	128° 43.2'	115
PAN77-105	50° 44.0'	128° 46.3'	122
PAN77-106	50° 44.0'	128° 49.6'	140
PAN77-107	50° 41.9'	128° 49.5'	170
PAN77-108	50° 40.0'	128° 49.5'	220
PAN77-110	50° 40.1'	128° 46.3'	260
PAN77-111	50° 42.0'	128° 46.2'	150
PAN77-112	50° 42.0'	128° 42.9'	150
PAN77-115	50° 46.0'	128° 27.3'	49
PAN77-116	50° 46.0'	128° 30.5'	71
PAN77-117	50° 48.0'	128° 32.3'	59
PAN77-118	50° 50.3'	128° 31.7'	24
PAN77-119	50° 50.2'	128° 29.2'	58
PAN77-120	50° 50.3'	128° 26.0'	58
PAN77-121	50° 50.4'	128° 22.6'	30
PAN78-3	50° 40.1'	128° 33.0'	
PAN78-4	50° 45.9'	128° 36.6'	
PAN78-5	50° 46.2'	128° 39.5'	79
PAN78-6	50° 48.0'	128° 43.1'	71
PAN78-7	50° 50.6'	128° 46.3'	71
PAN78-8	50° 50.9'	128° 52.0'	79

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
PAR76-140	0	83.3	16.7		
PAR76-141	0	94.8	5.2		
PAR76-142	0	98.8	1.2		
PAR76-143	0	99.6	0.4		
PAR76-144	0	100	0		
PAR76-145	0.2	99.5	0.3		
PAR76-146	0	99.7	0.3		
PAR76-147	99.9	0.1	0		
PAR76-148	99.2	0.8	0		
PAR76-149	99.7	0.3	0		
PAR76-150	7.2	92.6	0.2		
PAR76-151	99.9	0.1	0		
PAR76-152	98.6	1.4	0		
PAR76-153	70.6	28.6	0.8		
PAN77-2	0.2	92.1	2.2	0.5	99
PAN77-3	0.0	87.8	10.5	1.5	
PAN77-4	0.0	85.2	14.8	1.5	
PAN77-74	100.0	0.0	0.0		
PAN77-80	70.2	29.6	0.2	9.5	
PAN77-81	0.0	99.5	0.5	2.0	
PAN77-82	0.0	100.0	0.0	4.5	
PAN77-83	0.0	100.0	0.0	17.5	
PAN77-84	0.0	100.0	0.0	1.0	
PAN77-85	0.0	98.1	1.9	1.0	
PAN77-86	0.0	100.0	0.0	1.5	
PAN77-87	0.0	99.4	0.6	1.0	
PAN77-88	0.0	97.3	2.7	2.5	
PAN77-89	88.9	10.8	0.3	6.5	
PAN77-90	0.0	100.0	0.0	1.5	
PAN77-104	34.9	65.1	0.0	2.5	
PAN77-105	8.2	88.1	3.7	6.5	
PAN77-106	0.0	100.0	0.0	2.5	
PAN77-107	0.0	99.9	0.1	1.0	
PAN77-108	71.1	28.9	0.0	3.5	
PAN77-110	0.0	91.5	8.5	1.5	
PAN77-111				17.0	
PAN77-112	0.0	97.7	2.3	2.0	
PAN77-115				53.5	
PAN77-116	100.0	0.0	0.0		
PAN77-117					100
PAN77-118	100.0	0.0	0.0		
PAN77-119	100.0	0.0	0.0	65.5	
PAN77-120				0.5	
PAN77-121					
PAN78-3				92.5	100
PAN78-4				94.5	50
PAN78-5	20.9	79.0	0.1	17.5	
PAN78-6	72.4	27.4	0.2	45.0	10
PAN78-7				83.5	90
PAN78-8				88.5	75

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (M)
PAN78-9	50 ° 48.6 '	128 ° 50.7 '	68
PAN78-10	50 ° 47.9 '	128 ° 52.8 '	73
PAN78-11	50 ° 47.6 '	128 ° 50.5 '	84
PAN78-12	50 ° 46.1 '	128 ° 56.4 '	22
PAN78-13	50 ° 46.4 '	128 ° 52.0 '	93
PAN78-14	50 ° 46.0 '	128 ° 49.5 '	101
PAN78-15	50 ° 46.1 '	128 ° 43.5 '	73
PAN78-16	50 ° 46.0 '	128 ° 46.3 '	90
PAN78-17a	50 ° 44.4 '	128 ° 53.2 '	146
PAN78-18	50 ° 44.5 '	128 ° 56.4 '	148
PAN78-19	50 ° 44.7 '	128 ° 59.3 '	148
PAN78-20	50 ° 46.3 '	128 ° 59.4 '	113
PAN78-21	50 ° 48.1 '	128 ° 59.7 '	108
PAN78-22	50 ° 42.5 '	128 ° 53.2 '	186
PAN78-23	50 ° 42.3 '	128 ° 55.9 '	201
PAN78-24	50 ° 42.4 '	129 ° 0.3 '	207
PAN78-25	50 ° 45.3 '	129 ° 3.7 '	143
PAN78-26	50 ° 47.2 '	129 ° 2.9 '	117
PAN78-27	50 ° 48.9 '	129 ° 2.8 '	
PAN78-28	50 ° 44.4 '	129 ° 5.0 '	
PAN78-29	50 ° 46.4 '	129 ° 5.5 '	132
PAN78-30	50 ° 45.2 '	129 ° 4.6 '	110
PAN78-31	50 ° 50.2 '	129 ° 6.1 '	70
PAN78-32	50 ° 52.5 '	129 ° 8.9 '	58
PAN78-33	50 ° 50.4 '	129 ° 9.4 '	80
PAN78-34	50 ° 48.4 '	129 ° 9.3 '	95
PAN78-35	50 ° 46.7 '	129 ° 9.9 '	143
PAN78-36	50 ° 44.8 '	129 ° 10.0 '	66
PAN78-37	50 ° 50.5 '	129 ° 12.4 '	88
PAN78-38	50 ° 48.5 '	129 ° 13.0 '	122
PAN78-39	50 ° 46.5 '	129 ° 12.2 '	143
PAN78-40	50 ° 44.9 '	129 ° 13.3 '	161
PAN78-41	50 ° 44.3 '	129 ° 15.3 '	220
PAN78-42	50 ° 46.4 '	129 ° 15.7 '	157
PAN78-43	50 ° 48.4 '	129 ° 15.7 '	141
PAN78-44	50 ° 50.6 '	129 ° 15.3 '	113
PAN78-45	50 ° 52.7 '	129 ° 15.1 '	110
PAN78-46	50 ° 54.8 '	129 ° 15.0 '	95
PAN78-47	50 ° 54.6 '	129 ° 18.3 '	141
PAN78-48	50 ° 52.9 '	129 ° 18.1 '	132
PAN78-49	50 ° 50.7 '	129 ° 18.7 '	143
PAN78-50	50 ° 48.7 '	129 ° 19.1 '	141
PAN78-51	50 ° 46.9 '	129 ° 19.6 '	155
PAN78-52	50 ° 47.7 '	129 ° 23.3 '	201
PAN78-53	50 ° 48.7 '	129 ° 22.3 '	165
PAN78-54	50 ° 50.9 '	129 ° 22.0 '	170
PAN78-55	50 ° 52.9 '	129 ° 22.0 '	170
PAN78-56	50 ° 55.1 '	129 ° 21.5 '	170
PAN78-57	50 ° 55.1 '	129 ° 25.3 '	185
PAN78-58	50 ° 53.2 '	129 ° 25.2 '	179

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
PAN78-9				90.0	
PAN78-10					95
PAN78-11					
PAN78-12					
PAN78-13	0.1	99.8	0.1	5.0	
PAN78-14	30.5	69.4	0.1	21.5	
PAN78-15				28.0	
PAN78-16	61.5	38.3	0.2		
PAN78-17a	97.8	2.1	0.1	6.5	
PAN78-18	95.7	4.2	0.1	15.0	
PAN78-19	80.7	18.8	0.5	35.5	
PAN78-20					
PAN78-21	13.5	86.1	0.4	5.0	5
PAN78-22	0.0	96.2	3.8	2.0	
PAN78-23	24.5	73.8	1.7		
PAN78-24	0	96.2	3.8	2.0	15
PAN78-25	7.8	92.1	0.1	10.5	15
PAN78-26	0.9	98.7	0.3	3.0	15
PAN78-27	74.6	24.9	0.5	42.5	5
PAN78-28	48.4	40.7	10.9	45.5	5
PAN78-29					
PAN78-30	19.3	80.1	0.6	3.0	5
PAN78-31					
PAN78-32					
PAN78-33	92.0	8.0	0.0	35.0	5
PAN78-34	0.8	99.0	0.2	3.5	25
PAN78-35	66.4	32.5	1.1	37.5	5
PAN78-36					
PAN78-37					
PAN78-38	38.8	60.3	0.9	4.0	
PAN78-39	52.9	45.8	1.3	31.0	
PAN78-40					
PAN78-41	3.1	90.2	6.7	5.0	
PAN78-42				21.5	
PAN78-43	73.7	24.9	1.4	11.0	5
PAN78-44	61.5	38.1	0.4	41.5	15
PAN78-45				43.5	
PAN78-46					
PAN78-47				44.0	
PAN78-48	48.1	49.7	2.2	35.0	5
PAN78-49	61.5	32.9	5.6	37.0	5
PAN78-50					
PAN78-51					
PAN78-52	0.2	97.0	2.8	10.5	
PAN78-53	29.5	63.2	7.3	33.0	5
PAN78-54	0.0	95.6	4.4	2.5	5
PAN78-55	0.0	84.9	15.1	5.5	
PAN78-56	0.0	85.2	14.8	3.5	
PAN78-57	0.0	74.4	25.6	7.0	
PAN78-58	54.1	38.5	7.4	25.5	

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (M)
PAN78-59	50° 51.3'	129° 25.1'	183
PAN78-60	50° 53.6'	129° 28.5'	185
PAN78-62	50° 55.0'	129° 28.6'	188
PAN78-63	50° 54.5'	129° 11.7'	82
PAN78-64	50° 52.5'	129° 12.0'	84
PAN78-65	50° 50.8'	128° 29.9'	60
PAN78-66	50° 52.7'	128° 30.0'	71
PAN78-67	50° 52.3'	128° 33.3'	51
PAN78-68	50° 50.7'	128° 36.7'	44
PAN78-69	50° 52.4'	128° 39.6'	70
PAN78-70	50° 52.7'	128° 43.0'	64
PAN78-71	50° 52.8'	128° 45.8'	64
PAN78-72	50° 52.3'	128° 49.2'	70
PAN78-73	50° 52.4'	128° 52.7'	90
PAN78-74	50° 52.7'	128° 56.2'	106
PAN78-75	50° 52.8'	128° 59.6'	57
PAN78-76	50° 53.1'	129° 2.9'	
PAN78-77	50° 54.9'	129° 8.6'	
PAN78-78	50° 54.8'	129° 2.2'	70
PAN78-79	50° 54.8'	129° 5.0'	90
PAN78-80	50° 54.2'	129° 0.6'	70
PAN78-81	50° 54.6'	128° 56.0'	88
PAN78-82	50° 54.6'	128° 52.9'	73
PAN78-83	50° 54.5'	128° 29.5'	71
PAN78-84	50° 54.3'	128° 33.2'	51
PAN78-85	50° 54.2'	128° 36.2'	64
PAN78-86	50° 54.2'	128° 39.3'	90
PAN78-87	50° 54.6'	128° 42.9'	73
PAN78-88	50° 54.9'	128° 45.7'	79
PAN78-89	50° 54.9'	128° 49.0'	73
PAN78-90a	50° 50.5'	128° 52.4'	71
PAN78-90b	50° 50.5'	128° 53.0'	68
PAN78-91	50° 50.5'	128° 55.9'	88
PAN78-92	50° 50.5'	128° 59.5'	91
PAN78-93	50° 50.1'	129° 2.8'	45
PAN78-94	50° 45.0'	128° 47.7'	115
PAN78-95	50° 45.3'	128° 44.5'	93
PAN78-96	50° 44.9'	128° 43.9'	106
PAN78-97	50° 45.3'	128° 43.1'	93
PAN78-98	50° 45.6'	128° 40.9'	95
PAN78-99	50° 44.9'	128° 37.6'	95
PAN78-100	50° 44.8'	128° 35.5'	88
PAN78-101	50° 44.6'	128° 33.2'	91
PAN78-102	50° 45.1'	128° 32.7'	82
PAN78-103	50° 44.2'	128° 32.4'	82
PAN78-104	50° 44.7'	128° 31.0'	88
PAN78-105	50° 44.5'	128° 29.5'	90
PAN78-106	50° 44.1'	128° 29.6'	
PAN78-107	50° 44.5'	128° 28.0'	64
PAN78-108	50° 48.7'	128° 48.5'	110

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
PAN78-59	11.0	77.6	11.4	8.0	5
PAN78-60	40.0	52.8	7.2	12.0	
PAN78-62	1.8	82.8	15.4	37.5	
PAN78-63					
PAN78-64				62.5	
PAN78-65					100
PAN78-66	13.0	85.3	1.7	37.5	90
PAN78-67				33.5	40
PAN78-68				33.0	40
PAN78-69				79.5	60
PAN78-70				64.0	50
PAN78-71				90.0	75
PAN78-72	86.4	12.9	0.7	61.0	25
PAN78-73	81.0	17.1	1.9	48.0	
PAN78-74					60
PAN78-75				90.0	75
PAN78-76					95
PAN78-77					
PAN78-78					
PAN78-79	56.2	43.7	0.1	6.5	5
PAN78-80	8.2	90.5	1.3	28.5	99
PAN78-81				86.0	90
PAN78-82				81.0	95
PAN78-83	1.0	97.3	1.7	22.0	
PAN78-84					
PAN78-85	29.0	69.3	1.7	80.0	40
PAN78-86				91.5	99
PAN78-87				67.5	50
PAN78-88				47.5	60
PAN78-89				36.5	10
PAN78-90a					99
PAN78-90b				98.0	99
PAN78-91				93.5	99
PAN78-92	77.1	22.0	0.9	65.5	
PAN78-93	34.0	65.0	1.0	64.0	5
PAN78-94	19.5	79.5	1.0	10.5	
PAN78-95					
PAN78-96	71.3	28.4	0.3	10.0	
PAN78-97	1.7	97.9	0.4	8.0	
PAN78-98	54.3	39.0	6.7	26.0	
PAN78-99	58.0	41.2	0.8	34.5	
PAN78-100	2.4	97.4	0.2	6.0	50
PAN78-101	1.7	97.2	1.1	6.0	
PAN78-102	33.4	65.7	0.9	3.5	25
PAN78-103	1.8	96.9	1.3	17.5	
PAN78-104	0.2	98.7	1.1	6.0	99
PAN78-105	13.5	86.3	0.2	3.0	
PAN78-106	0.3	98.8	0.9	2.5	
PAN78-107	88.3	11.3	0.4	24.5	
PAN78-108	24.9	72.9	2.2	50.0	25

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (M)
PAN78-109	50° 46.7'	128° 47.7'	106
PAN78-110	50° 43.2'	128° 42.8'	128
PAN78-111	50° 43.1'	128° 41.0'	128
PAN78-112	50° 43.3'	128° 36.8'	122
PAN78-113	50° 42.9'	128° 36.3'	122
PAN78-116	50° 40.9'	128° 25.6'	73
PAN78-117	50° 43.1'	128° 25.7'	68
PAN78-118	50° 43.2'	128° 28.7'	86
PAN78-119	50° 42.9'	128° 33.5'	99
PAN78-120	50° 40.9'	128° 31.9'	113
PAN78-123	50° 40.9'	128° 28.7'	88
GBR82-21	50° 57.8'	128° 59.1'	70
GBR82-22	50° 57.1'	129° 12.4'	128
GBR82-24	51° 1.1'	128° 15.1'	117
GBR82-25	51° 1.1'	128° 9.8'	
GBR82-26	51° 5.4'	128° 32.3'	128
GBR82-27	51° 5.2'	128° 35.8'	110
GBR82-28	51° 3.6'	128° 36.2'	91
GBR82-29	51° 8.0'	128° 52.9'	99
GBR82-30	51° 4.1'	128° 39.5'	71
END83B-1	50° 52.5'	128° 31.0'	60
END83B-3	50° 51.3'	128° 32.5'	50
END83B-4	50° 48.8'	128° 31.6'	42
END83B-5	50° 49.8'	128° 30.8'	57
END83B-6	50° 52.0'	128° 29.2'	53
END83B-7	50° 51.3'	128° 31.5'	
END83B-8	50° 51.5'	128° 29.8'	
END83B-9	50° 52.9'	128° 28.7'	53
END83B-10	50° 53.9'	128° 28.5'	58
END83B-11	50° 51.6'	128° 27.5'	
END83B-12	50° 52.0'	128° 25.3'	47
END83B-13	50° 52.1'	128° 25.1'	45
END83B-14a	50° 52.2'	128° 21.2'	42
END83B-14b	50° 52.2'	128° 21.2'	42
END83B-15	50° 52.2'	128° 19.1'	
END83B-16	50° 52.2'	128° 13.6'	40
END83B-17	50° 50.5'	128° 16.3'	
END83B-18	50° 51.1'	128° 14.1'	26
END83B-19	50° 50.8'	128° 14.7'	
END83B-20	50° 50.9'	128° 16.6'	
END83B-21	50° 50.9'	128° 18.4'	32
END83B-22	50° 50.9'	128° 20.5'	35
END83B-23	50° 50.8'	128° 22.5'	36
END83B-24	50° 51.1'	128° 24.5'	48
END83B-25	50° 50.9'	128° 28.6'	44
END83B-26	° '	° '	
END83B-27	50° 49.4'	128° 29.3'	37
END83B-28	50° 49.5'	128° 27.2'	59
END83B-29a	50° 49.5'	128° 25.1'	33
END83B-29b	50° 49.5'	128° 25.1'	33

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
PAN78-109	21.2	77.7	1.1	4.0	
PAN78-110	0.1	98.8	1.1	2.5	
PAN78-111	0.1	98.5	1.4	2.5	
PAN78-112	0.6	97.0	2.4	4.0	
PAN78-113	0.1	98.9	1.0	3.0	
PAN78-116	77.9	21.6	0.5	3.5	5
PAN78-117	85.2	14.3	0.5	11.5	5
PAN78-118	0.7	98.3	1.0	3.0	99
PAN78-119	0.2	98.8	1.0	3.0	25
PAN78-120	0.1	99.4	0.5	3.5	90
PAN78-123	90.8	8.4	0.8	3.5	15
GBR82-21	0.0	99.0	1.0		
GBR82-22	0.0	98.4	1.6		
GBR82-24	0.0	95.2	4.8		
GBR82-25					
GBR82-26	0.0	90.1	9.9		
GBR82-27	0.0	95.8	4.2		
GBR82-28	0.0	98.8	1.2		
GBR82-29	0.0	98.8	1.2		
GBR82-30	0.0	99.1	0.9		
END83B-1	1.6	97.1	1.3	24.5	
END83B-3	21.1	77.1	1.8	54.0	
END83B-4	83.5	15.5	1.0	76.0	
END83B-5	77.0	21.2	1.8		
END83B-6	88.9	6.3	4.8		
END83B-7					
END83B-8					
END83B-9	35.4	62.6	2.0	34.0	
END83B-10	63.0	31.7	5.3	52.0	
END83B-11					
END83B-12	86.1	11.5	2.4		
END83B-13	33.3	65.0	1.7	74.5	
END83B-14a	58.6	40.9	0.5	49.5	
END83B-14b	1.5	97.5	1.0	26.0	
END83B-15					
END83B-16	0.0	99.0	1.0	6.5	
END83B-17					
END83B-18	97.2	2.4	0.4		
END83B-19					
END83B-20					
END83B-21	93.7	6.0	0.3	40.5	
END83B-22	76.6	22.9	0.5	51.5	
END83B-23	55.5	42.2	2.3	52.5	
END83B-24	30.9	66.8	2.3		
END83B-25	53.1	44.2	2.8	49.0	
END83B-26				41.5	
END83B-27	100.0	0.0	0.0		
END83B-28	61.0	37.5	1.5		
END83B-29a	10.9	88.1	1.0	61.0	
END83B-29b	21.0	78.2	0.8		

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (M)
END83B-31	50 ° 51.5 '	128 ° 24.2 '	44
END83B-32	50 ° 54.5 '	128 ° 29.0 '	73
END83B-33	50 ° 53.3 '	128 ° 30.1 '	66
END83B-34	50 ° 52.2 '	128 ° 31.1 '	68
END83B-35	50 ° 50.6 '	128 ° 32.2 '	52
END83B-36	50 ° 50.5 '	128 ° 34.6 '	47
END83B-37	50 ° 52.0 '	128 ° 33.4 '	51
END83B-38	50 ° 51.3 '	128 ° 32.5 '	50
END83B-39	50 ° 54.5 '	128 ° 31.4 '	30
END83B-40	50 ° 54.7 '	128 ° 33.1 '	45
END83B-43	50 ° 51.1 '	128 ° 35.9 '	44
END83B-44	° '	° '	
END83B-45	50 ° 54.6 '	128 ° 31.2 '	65
END83B-46	50 ° 54.4 '	128 ° 29.4 '	49
END83B-47	50 ° 54.4 '	128 ° 27.4 '	70
END83B-48	50 ° 54.5 '	128 ° 25.4 '	46
END83B-49	50 ° 54.4 '	128 ° 23.5 '	46
END83B-50	50 ° 54.3 '	128 ° 21.5 '	53
END83B-51	50 ° 53.8 '	128 ° 21.0 '	80
END83B-52	50 ° 54.2 '	128 ° 19.7 '	
END83B-53	50 ° 54.1 '	128 ° 17.7 '	
END83B-54	50 ° 54.0 '	128 ° 15.9 '	
END83B-55	50 ° 53.9 '	128 ° 14.0 '	47
END83B-56	50 ° 53.5 '	128 ° 6.5 '	39
END83B-57	50 ° 53.8 '	128 ° 12 '	33
END83B-58	° '	° '	
END83B-59	51 ° 3.8 '	128 ° 55.9 '	86
END83B-60	51 ° 2.6 '	128 ° 57.0 '	85
END83B-61	51 ° 3.8 '	128 ° 55.9 '	82
END83B-62a	51 ° 3.8 '	128 ° 55.8 '	86
END83B-62b	51 ° 3.8 '	128 ° 55.8 '	86
END83B-63	51 ° 4.5 '	128 ° 56.3 '	91
END83B-65	51 ° 3.9 '	128 ° 59.0 '	100
END83B-66	51 ° 3.9 '	129 ° 0.0 '	101
END83B-67	51 ° 6.3 '	128 ° 58.8 '	108
END83B-68	51 ° 4.1 '	129 ° 1.8 '	112
END83B-69	50 ° 59.0 '	128 ° 29.8 '	95
END83B-71	50 ° 58.9 '	128 ° 27.7 '	95
END83B-72	50 ° 59.0 '	128 ° 25.5 '	82
END83B-73	50 ° 58.9 '	128 ° 23.9 '	71
END83B-74	50 ° 59.6 '	128 ° 23.3 '	83
END83B-75	50 ° 59.7 '	128 ° 25.1 '	91
END83B-76	50 ° 59.9 '	128 ° 26.9 '	95
END83B-77	51 ° 0.1 '	128 ° 29.0 '	90
END83B-78	50 ° 59.7 '	128 ° 25.1 '	92
END83B-79	51 ° 0.7 '	128 ° 22.9 '	82
END83B-80	51 ° 0.7 '	128 ° 24.5 '	91
END83B-81	51 ° 0.9 '	128 ° 26.3 '	97
END83B-82	51 ° 1.0 '	128 ° 28.2 '	91
END83B-83	51 ° 2.1 '	128 ° 27.3 '	100

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
END83B-31	83.8	15.4	0.8		
END83B-32	2.7	95.8	1.5	16.5	
END83B-33	5.2	93.3	1.5	15.5	
END83B-34	23.5	73.6	2.9	57.5	
END83B-35	29.4	69.0	1.6	66.5	
END83B-36	11.6	87.0	1.4	38.0	
END83B-37	7.2	91.7	1.1		
END83B-38	21.1	76.6	2.3		
END83B-39	1.3	97.6	1.1		
END83B-40	0.0	97.6	2.4	19.5	
END83B-43	16.9	81.6	1.5	32.0	
END83B-44				16.0	
END83B-45	2.7	95.2	2.1	13.0	
END83B-46	0.0	97.4	2.6	25.5	
END83B-47	0.1	98.8	1.1	25.0	
END83B-48	0.5	98.5	1.0	13.0	
END83B-49	95.7	3.9	0.4		
END83B-50	100.0	0.0	0.0		
END83B-51	0.0	98.0	2.0	24.0	
END83B-52					
END83B-53					
END83B-54					
END83B-55	90.3	9.2	0.5		
END83B-56	64.9	34.8	1.3	12.5	
END83B-57	99.8	0.2	0.0		
END83B-58				6.5	
END83B-59	0.0	98.8	1.2		
END83B-60	0.0	98.0	2.0		
END83B-61	0.0	99.0	1.0	1.5	
END83B-62a	0.0	98.3	1.7	1.5	
END83B-62b	0.0	98.7	1.3		
END83B-63	0.0	98.9	1.1	3.0	
END83B-65	0.0	98.5	1.5	2.0	
END83B-66	0.0	98.6	1.4	1.0	
END83B-67	81.9	16.3	1.8	8.0	
END83B-68	0.0	97.4	2.6	3.0	
END83B-69	0.0	98.2	1.8	4.5	
END83B-71	0.0	97.7	2.3		
END83B-72	70.7	27.8	1.5	4.5	
END83B-73	87.8	11.7	0.5	6.0	
END83B-74	0.0	98.7	1.3	3.5	
END83B-75	0.0	98.3	1.7	3.5	
END83B-76	0.0	98.6	1.4	3.5	
END83B-77	2.2	96.1	1.7	4.5	
END83B-78	0.0	96.2	3.8		
END83B-79	58.4	40.2	1.4		
END83B-80	100.0	0.0	0.0		
END83B-81	0.1	98.1	1.8		
END83B-82	22.4	76.7	0.9		
END83B-83	95.4	3.5	1.1		

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (M)
END83B-84	51° 1.9'	128° 25.5'	109
END83B-85	51° 1.7'	128° 23.6'	103
END83B-86	51° 1.5'	128° 21.9'	97
END83B-116	50° 53.1'	128° 20.7'	66
END83B-117	50° 53.0'	128° 22.6'	46
END83B-118	50° 53.0'	128° 24.7'	53
END83B-119	50° 50.5'	128° 26.5'	51
END83B-120	50° 50.6'	128° 28.7'	40
END83B-121	50° 49.4'	128° 25.5'	43
END83B-122	50° 49.4'	128° 27.6'	37
END83B-123	50° 49.4'	128° 29.5'	35
END83B-124	50° 49.0'	128° 31.5'	39
END83B-125	50° 50.5'	128° 35.5'	40
END83B-126	50° 50.7'	128° 36.5'	48
END83B-127	50° 49.8'	128° 23.1'	33
PAR86A-27	51° 10.0'	128° 45.9'	100
PAR86A-28	51° 9.9'	128° 44.3'	95
PAR86A-29	51° 9.7'	128° 42.2'	112
PAR86A-30	51° 9.5'	128° 40.6'	121
PAR86A-31	51° 9.4'	128° 38.7'	132
PAR86A-33	51° 9.9'	128° 45.0'	95
PAR86A-34	51° 9.8'	128° 43.3'	93
PAR86A-35	51° 9.5'	128° 41.1'	116
PAR86A-36	51° 9.3'	128° 39.6'	123
PAR86A-37	51° 9.3'	128° 39.6'	133
PAR86A-38	51° 9.4'	128° 48.5'	96
PAR86A-39	51° 9.2'	128° 46.7'	94
PAR86A-40	51° 9.1'	128° 44.8'	98
PAR86A-41	51° 8.9'	128° 43.3'	88
PAR86A-42	51° 8.8'	128° 41.5'	
PAR86A-43	51° 8.3'	128° 40.0'	118
PAR86A-44	51° 8.5'	128° 48.8'	95
PAR86A-45	51° 8.3'	128° 46.9'	90
PAR86A-46	51° 8.2'	128° 45.0'	88
PAR86A-47	51° 8.0'	128° 43.2'	96
PAR86A-48	51° 7.9'	128° 41.4'	97
PAR86A-49	51° 7.6'	128° 39.6'	109
PAR86A-50	51° 8.4'	128° 49.5'	91
PAR86A-51	51° 8.2'	128° 47.6'	93
PAR86A-52	51° 8.1'	128° 45.5'	90
PAR86A-53	51° 7.9'	128° 43.5'	91
PAR86A-54	51° 7.8	128° 41.9	89
PAR86A-55	51° 7.7	128° 39.9	108
PAR86A-56	51° 8.6	128° 49.7	93
PAR86A-57	51° 9.6	128° 43.1	
PAR86A-58	51° 9.5	128° 41.2	
PAR86A-59	51° 9.5	128° 41.5	
END87A-1	51° 8.4	128° 43.6	102
END87A-3	51° 10.0	128° 41.6	127
END87A-4	51° 8.5	128° 40.2	122

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
END83B-84	0.0	97.4	2.6		
END83B-85	62.8	35.9	1.2		
END83B-86	7.9	89.5	2.6		
END83B-116	3.1	95.6	1.3		
END83B-117	56.9	42.3	0.8		
END83B-118	16.6	82.4	1.0		
END83B-119	63.7	34.3	2.0		
END83B-120	95.3	1.0	3.7		
END83B-121	17.9	80.9	1.2		
END83B-122	27.6	71.4	1.5		
END83B-123	99.6	0.4	0.0		
END83B-124	98.9	0.8	0.3		
END83B-125	8.6	90.0	1.4		
END83B-126	45.2	52.8	2.0		
END83B-127	52.4	46.6	1.0		
PAR86A-27	0.0	99.2	0.8		
PAR86A-28	29.1	70.3	0.6		
PAR86A-29	40.1	58.3	1.6		
PAR86A-30	0.0	99.0	1.0		
PAR86A-31	0.0	98.8	1.2		
PAR86A-33	16.1	83.2	0.7		
PAR86A-34	50.4	47.0	2.6		
PAR86A-35	20.3	78.6	1.1		
PAR86A-36	0.0	98.8	1.2		
PAR86A-37	0.0	98.8	1.2		
PAR86A-38	25.8	72.7	1.5		
PAR86A-39	36.9	68.4	0.7		
PAR86A-40	63.5	35.6	0.9		
PAR86A-41	52.0	46.5	1.5		
PAR86A-42	57.2	41.4	1.4		
PAR86A-43	0.0	98.8	1.2		
PAR86A-44	0.0	99.2	0.8		
PAR86A-45	0.0	99.2	0.8		
PAR86A-46	58.5	40.9	0.6		
PAR86A-47	1.1	98.0	0.9		
PAR86A-48	0.0	99.2	0.8		
PAR86A-49	0.0	98.0	2.0		
PAR86A-50	0.0	99.2	0.8		
PAR86A-51	0.0	99.2	0.8		
PAR86A-52	27.4	71.8	0.8		
PAR86A-53	2.2	97.0	0.8		
PAR86A-54	2.1	97.0	0.9		
PAR86A-55	0.0	98.3	1.7		
PAR86A-56	0.0	99.1	0.9		
PAR86A-57					
PAR86A-58					
PAR86A-59					
END87A-1	10.3	83.8	5.9		
END87A-3	3.9	94.0	2.1		
END87A-4	0.0	99.7	0.3		

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (M)
END87A-5	51 ° 9.0	128 ° 41.9	110
END87A-6	51 ° 9.7	128 ° 46.8	
END87A-7	51 ° 7.6	128 ° 40.6	94
END87A-8	51 ° 8.9	128 ° 41.9	
END87A-9	51 ° 8.7	128 ° 40.2	
END87A-10	51 ° 9.3	128 ° 46.8	
END87A-14	51 ° 10.0	128 ° 37.1	150
END87A-20	50 ° 54.8	128 ° 41.3	
END87A-21a	50 ° 58.8	128 ° 37.6	
END87A-21b	50 ° 58.8	128 ° 37.6	68
END87A-22	50 ° 57.1	128 ° 31.0	104
END87A-23	50 ° 59.9	128 ° 26.6	98
END87A-24	51 ° 0.2	128 ° 26.5	
END87A-25	50 ° 58.0	128 ° 13.8	
END87A-27	50 ° 53.5	128 ° 34.3	
END87A-28	50 ° 54.3	128 ° 36.6	
END87A-29	50 ° 54.5	128 ° 39.4	
END87A-30	50 ° 54.5	128 ° 41.2	
END87A-31	50 ° 54.5	128 ° 43.6	
END87A-32	50 ° 54.4	128 ° 45.3	
END87A-33	50 ° 55.2	128 ° 47.4	
END87A-34	50 ° 55.2	128 ° 47.9	
END87A-35	50 ° 57.2	128 ° 51.5	83
END87A-36	50 ° 57.9	128 ° 53.8	
END87A-37	50 ° 58.3	128 ° 56.0	71
END87A-38	50 ° 58.9	128 ° 58.3	74
END87A-39	50 ° 59.5	129 ° 1.5	84
END87A-40	50 ° 59.9	129 ° 3.7	89
END87A-41	51 ° 0.7	129 ° 6.0	118
END87A-42	51 ° 5.0	128 ° 32.4	
END87A-43	51 ° 8.8	128 ° 33.5	104
END87A-44	51 ° 2.4	128 ° 34.7	88
END87A-46	50 ° 59.7	128 ° 37.1	66
END87A-47	50 ° 58.4	128 ° 38.1	
END87A-48	50 ° 57.1	128 ° 38.9	
END87A-49	50 ° 55.4	128 ° 40.9	
END87A-50	50 ° 53.9	128 ° 42.2	
END87A-51	51 ° 7.8	128 ° 57.9	115
END87A-52	51 ° 7.1	128 ° 54.4	98
END87A-53	51 ° 6.8	128 ° 52.3	
END87A-54	51 ° 6.3	128 ° 50	
END87A-55	51 ° 5.9	128 ° 48.6	68
END87A-56	51 ° 5.5	128 ° 46.2	64
END87A-57	51 ° 4.7	128 ° 43.6	64
END87A-58	51 ° 4.1	128 ° 41.1	67
END87A-59	51 ° 3.5	128 ° 38.6	
END87A-60	51 ° 3.1	128 ° 36.4	82
END87A-61	51 ° 2.6	128 ° 34.4	91
END87A-62	51 ° 1.8	128 ° 31.3	99
END87A-63	51 ° 1.1	128 ° 28.1	97

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CaCO3 SAND	% CaCO3 GRAVEL
END87A-5	4.3	92.7	3.0		
END87A-6					
END87A-7	3.2	96.5	0.3		
END87A-8					
END87A-9					
END87A-10					
END87A-14	0.0	97.8	2.2		
END87A-20					
END87A-21a					
END87A-21b	0.7	98.5	0.8		
END87A-22	0.0	93.8	6.2		
END87A-23	0.0	99.0	1.0		
END87A-24					
END87A-25					
END87A-27					
END87A-28					
END87A-29					
END87A-30					
END87A-31					
END87A-32					
END87A-33					
END87A-34					
END87A-35	0.1	98.8	1.1		
END87A-36					
END87A-37	37.1	62.1	0.8		
END87A-38	0.0	99.1	0.9		
END87A-39	0.0	99.0	1.0		
END87A-40	0.0	98.4	0.6		
END87A-41	0.0	97.3	2.7		
END87A-42					
END87A-43	0.0	98.5	1.5		
END87A-44	0.0	98.8	1.2		
END87A-46	0.1	99.1	0.8		
END87A-47					
END87A-48					
END87A-49					
END87A-50					
END87A-51	65.5	33.6	0.9		
END87A-52	14.3	83.7	2.0		
END87A-53					
END87A-54					
END87A-55	0.1	99.2	0.7		
END87A-56	63.7	35.9	0.4		
END87A-57	0.0	99.3	0.7		
END87A-58	0.0	99.1	0.9		
END87A-59					
END87A-60	0.0	98.9	1.1		
END87A-61	0.0	98.9	1.1		
END87A-62	0.0	98.4	1.6		
END87A-63	0.1	98.7	1.2		

SAMPLE NO.	LATITUDE (N)	LONGITUDE (W)	DEPTH (M)
END87A-64	50 ° 59.7	128 ° 26.9	
END87A-65	50 ° 59.7	128 ° 24.6	
END87A-66	50 ° 59.3	128 ° 22.9	
END87A-67	50 ° 58.9	128 ° 21.2	
END87A-68	50 ° 58.6	128 ° 19.5	68
END87A-69	50 ° 58.2	128 ° 17.6	81
END87A-70	50 ° 57.7	128 ° 15.8	74
END87A-71	50 ° 56.8	128 ° 12.1	61
END87A-72	51 ° 0.1	128 ° 29	94
END87A-73	50 ° 57.4	128 ° 31.5	
END87A-74	50 ° 57.5	128 ° 31.3	
END87A-75	51 ° 9.2	128 ° 42.6	
END87A-77	51 ° 8.2	128 ° 44.2	90
END87A-78	51 ° 4.2	129 ° 2.8	119
END87A-79	51 ° 3.6	129 ° 0	
END87A-80	51 ° 3.3	128 ° 58.9	
END87A-81	51 ° 3.1	128 ° 57.8	
END87A-82	51 ° 2.5	128 ° 54.7	75
END87A-83	51 ° 1.5	128 ° 50.7	61
END87A-84	51 ° 0.6	128 ° 46.5	66
END87A-85	50 ° 59.6	128 ° 42.9	73
END87A-86	50 ° 58.8	128 ° 38.4	
END87A-87	50 ° 57.7	128 ° 34.4	57
END87A-88	50 ° 56.8	128 ° 29.8	
END87A-89	50 ° 56.1	128 ° 26	
END87A-90	50 ° 55	128 ° 21.7	
END87A-91	50 ° 54.1	128 ° 17.9	
END87A-92	50 ° 53.3	128 ° 13.7	

SAMPLE NO.	GRAVEL (%)	SAND (%)	MUD (%)	% CACO3 SAND	% CACO3 GRAVEL
END87A-64					
END87A-65					
END87A-66					
END87A-67	72.8	24.9	2.3		
END87A-68	17.1	82.1	0.8		
END87A-69	0.0	99.0	1.0		
END87A-70	14.6	83.7	1.7		
END87A-71	43.3 *	56.2	0.5		
END87A-72	0.0	92.3	7.7		
END87A-73					
END87A-74					
END87A-75					
END87A-77	3.0	96.7	0.3		
END87A-78	0.0	97.2	2.8		
END87A-79					
END87A-80					
END87A-81					
END87A-82	0.0	99.1	0.9		
END87A-83	32.2	67.2	0.6		
END87A-84	1.6	97.5	0.9		
END87A-85	0.3	99.0	0.7		
END87A-86					
END87A-87	92.1	7.4	0.5		
END87A-88					
END87A-89					
END87A-90					
END87A-91					
END87A-92					

B. Pebble Lithology Data

1. Raw Pebble Lithology Data

Explanation of Tables

The first number in the column is the sample number used for pebble lithology and indicates the sample designation used on the cluster analysis dendrogram (Figure 18).

SAMPLE NO. - the official sample designation. See appendix A.1. for explanation.

P - percentage of plutonic rocks, primarily granite and syenite, some granodiorite.

V - percentage of volcanic rocks, mostly rhyolites and andesites. Some basalts may have been classed as miscellaneous, if they were not vessicular or porphyritic.

S - percentage of sedimentary rocks. Most are dark-coloured, lithic sandstones and siltstones. No carbonates were identified.

Q - percentage of grains composed entirely or almost entirely of quartz. Most were small (< 1cm) pebbles or granules.

M - percentage of miscellaneous rocks. These rocks include some gneisses, but most are fine-grained, black rocks. May include mafic mineral pebbles, basalt, and fine-grained metamorphic rocks.

CLASS - indicates the lithology class this sample was assigned to in the cluster analysis. See Appendix B.2. for more information.

	SAMPLE NO.	P	V	S	Q	M
1	GBR79A-93	30	4	24	0	42
2	GBR79A-96	24	6	22	6	42
3	GBR79A-132	34	2	26	10	28
4	GBR79A-143	46	6	16	4	28
5	GBR79A-151	24	6	22	2	46
6	GBR79A-170	20	8	22	0	50
7	GBR79B-11	20	2	30	0	48
8	GBR79B-50	6	10	13	0	71
9	GBR79B-55	28	0	26	14	32
10	GBR79B-66	26	0	14	8	52
11	GBR79B-78	22	16	34	0	28
12	VEC81B-38	14	2	38	4	42
13	VEC81B-85	4	21	21	4	50
14	PAR83A-6	18	14	34	2	32
15	GBR83A-8	22	10	24	8	36
16	GBR83A-9	22	6	28	4	40
17	GBR83A-10	22	10	24	8	36
18	GBR83A-12	22	6	28	6	38
19	GBR83A-14b	24	8	24	10	34
20	GBR83A-15	22	18	26	2	32
21	GBR83A-16	30	14	18	8	30
22	GBR83A-18	34	6	20	2	38
23	GBR83A-21	6	14	30	6	44
24	GBR83A-22b	16	10	28	4	42
25	GBR83A-23	20	12	28	0	40
26	GBR83A-24	36	12	16	2	34
27	GBR83A-25	14	12	22	2	50
28	GBR83A-26	29	13	19	2	37
29	GBR83A-28	28	6	24	8	34
30	GBR84A-89	10	6	24	8	52
31	GBR84A-100	26	2	14	18	40
32	GBR84-103	14	14	18	2	52
33	GBR84A-126	24	4	26	0	46
34	GBR84A-128	18	18	16	2	46
35	GBR84A-130	30	12	28	4	26
36	GBR84A-132	12	8	30	0	50
37	GBR85A-25	18	8	26	6	42
38	GBR85A-28	20	10	22	10	38
39	GBR85A-31	46	8	18	4	24

2. Cluster Analysis

The first step of the cluster analysis was the calculation of a distance coefficient for each pair of samples. This was defined as the square root of the sum of the squares of the differences between each descriptor in the two samples, giving a number between 0 (identical) and 1 (completely different). e.g.

	P	V	S	Q	M	SUM
Sample 1	0.30	0.04	0.24	0.00	0.42	
Sample 2	0.24	0.06	0.22	0.06	0.42	
Difference	0.06	0.02	0.02	0.06	0.00	
Square	0.0036	0.0004	0.0004	0.0036	0.0000	0.0080

The distance coefficient is the square root of 0.008 or 0.089. A BASIC program was written to make this calculation for the 39 samples.

Once the distance coefficients were obtained, the samples were clustered. This was done by advancing the threshold criterion distance from 0 to 1 until the criterion distance exceeded the actual distance between two samples. At that point the two samples were clustered.

Once a cluster of more than one sample was formed, the addition of other samples occurred only when the threshold criterion exceeded the distance between the sample outside the cluster and the MOST distant of the samples within the cluster. This is called a farthest-neighbour or complete-linkage clustering method.

e.g. the distances between hypothetical samples A, B, and C are shown below:

	A	B	C
A	0.00	0.16	0.47
B	0.16	0.00	0.55
C	0.47	0.55	0.00

Because A and B cluster together first (at a criterion distance of 0.16), C is not added to the cluster until the criterion distance reaches 0.55. Although the distance between A and C is only 0.47, C cannot be added until the criterion distance exceeds the distance between B and C.

The resulting clusters were then plotted as a dendrogram (Figure 18), which shows the criterion distance at which the clustering of the samples occurs.

C. Faunal Data

1. Taxonomy

The author used only those names listed in Kozloff (1987). However, in order to use the environmental data provided by Bernard (1970) and Abbott (1974), and to combine the data collected in this study with that of Lee & Adkins (1979) and J.C. Lee and Associates (1982), it was necessary to determine the equivalent names in those authors. In many cases, the equivalents were specifically mentioned. For example, Abbott (1974) explicitly regards Tellina salmonea, a species referred to in Bernard (1970) as a synonym of Tellina nucleoides. In other cases, the species has simply been assigned to a different genus in Kozloff (1987) than in earlier works. For example, Nitidiscala, regarded by Abbott (1974) as a subgenus of Epitonium, has been assigned genus status by Kozloff (1987). In a few cases, it was necessary to go through the identification keys to determine the Kozloff(1987) name; in cases where identification was doubtful, a question mark has been placed on the equivalencies. One species found by Lee & Adkins (1979), Cerithiopsis truncatum had no clear equivalent listed by Kozloff (1987).

The following page lists the Kozloff (1987) names, together with the names used by Bernard (1970), Abbott (1974), Lee & Adkins (1979) and J.C. Lee & Associates (1982).

Kozloff (1987) Name		*Equivalents in Lee & Associates or Bernard(1970)*
Spiromoelleria quadrae	(Dall, 1897)	= *Molleria quadrae*
Homalapoma luridum	(Dall, 1885)	= *H. carpenteri (Pilsbry, 1888)*
Margarites marginatus	Dall, 1919	= *M. helicinus (Phipps, 1774)*
Lottia pelta	(Rathke, 1833)	= *Acmaea pelta*
Tectura persona	(Rathke, 1833)	= *Notoacmaea persona*
Lepeta caeca	(Muller, 1776)	= *Lepeta caecoides*
Micranellum crebricinctum	(Carpenter, 1864)	=*Caecum crebricinctum*
Petaloconchus compactus	(Carpenter, 1864)	= *Vermetus compactus*
Cerithiopsis stejnegeri	Dall, 1884	= *C. stephensae*
Crepidula dorsata	(Broderip, 1834)	= *Crepipatella lingulata (Gould, 1846)*
Polinices pallidus	(Broderip and Sowerby, 1829)	= *Lunatia pallida*
Nitidiscala indianorum	(Carpenter, 1864)	= *Epitonium indianorum*
Epitonium greenlandicum	(Perry, 1811)	= *? Opalia montereyensis?*
Opalia borealis	Keep, 1881	= *O. wroblebskii*
Eulima micans	(Carpenter, 1864)	= *Balcis micans*
Sabinella ptilocrinicola	(Bartsch, 1907)	= *Balcis ptilocrinicola*
Nucella emarginata	(Deshayes, 1839)	= *Thais emarginata*
Ocenebra interfossa	Carpenter, 1864	= *Tritonalia interfossa*
Ocenebra lurida	(Middendorff, 1848)	= *Urosalpinx lurida*
Trophonopsis pacificus	Dall, 1902	= *Trophon beringi (Dall, 1902)*
Trophonopsis lasius	(Dall, 1919)	= *Trophon tenuisculptus Carpenter*
Alia gausapata	(Carpenter, 1864)	= *Mitrella gausapata, Alia gausapata*
Alia permodesta	(Dall, 1890)	= *Mitrella permodesta*
Oenopota crebicostata	(Carpenter, 1864)	= *Mangelia crebicostata*
Oenopota turricula	(Montagu, 1803)	= *Propebela turricula*
Cylichnella culcitella	(Gould, 1852)	= *Acteocina culcitella*
Chlamys hastata	(Sowerby, 1843)	=*C. hericia*
Pododesmus cepio	(Gray, 1850)	= *P. macroschisma*
Lucinoma tennuisculpta	(Carpenter, 1865)	=*Parvilucina tennuisculpta*
Diplodonta orbella	(Gould, 1851)	= *D. orbellus (Gould, 1852)*
Miodontiscus prolongatus	(Carpenter, 1864)	= *M. prolongata*
Tridonta alaskensis	Dall, 1903	= *Astarte alaskensis*
Spisula falcata	(Gould, 1850)	*S. polynyma*
Tellina nucleoides	(Reeve, 1854)	= *T. salmonea*
Protothaca staminea	(Conrad, 1857)	*Called Venerupis in Bernard?*
Pandora wardiana	A. Adams, 1859	=*P. grandis*
	No Kozloff Equivalent	
Cerithiopsis truncatum	Dall, 1886	

2. Raw Data-Hecate Strait

Explanation of Tables

The following pages give the relative abundance of faunas, on the 0 to 6 scale described in III.B.4. Both data from J.C. Lee & Associates (1982) and this study are included. In general, results appear comparable at the genus level, although there are striking differences in the frequency of different species in certain genera between the two species, particularly *Nucella* and *Clinocardium*. *Pododesmus cepio*, although present, was unrecognized by the author. However, in most respects the results are similar.

The column numbers are the faunal sample designations; consult the chart on the next page to determine the grab sample that each column represents. The following samples were analysed within this study: 5,7,22,29,30,31,36,38,40, 41,43,62,65-87. Sample 1, included in the tables, was a Hecate Strait sample from north of the study area at 54°17.9'N, 131°25.2'W, in a water depth of 82m.

Faunal Sample Numbers for Hecate Strait Samples

2	GBR79A-70
3	GBR79A-85
4	GBR79A-90
5	GBR79A-96
6	GBR79A-100
7	GBR79A-132
8	GBR79A-153
9	GBR79A-154
10	GBR79A-157
11	GBR79A-178
12	GBR79A-180
13	GBR79A-193
14	GBR79A-194
15	GBR79A-203
16	GBR79A-233
17	GBR79A-235
18	GBR79A-239
19	GBR79A-244
20	GBR79B-5
21	GBR79B-6
22	GBR79B-11
23	GBR79B-22
24	GBR79B-34
25	GBR79B-35
26	GBR79B-36
27	GBR79B-37
28	GBR79B-44
29	GBR79B-55
30	GBR79B-66
31	GBR79B-78
32	VEC81B-14b
33	VEC81B-15
34	VEC81B-29
35	VEC81B-30
36	VEC81B-63
37	VEC81B-65
38	VEC81B-69
39	VEC81B-84
40	VEC81B-85
41	VEC81B-101
42	VEC81B-107
43	VEC81B-110
44	VEC81B-132
45	VEC81B-133
46	VEC81B-134
47	VEC81B-139
48	VEC81B-148b
49	VEC81B-153
50	VEC81B-156
51	VEC81B-163
52	VEC81B-169
53	VEC81B-171
54	VEC81B-173a
55	VEC81B-175
56	VEC81B-176
57	VEC81B-177
58	VEC81B-178
59	VEC81B-179
60	VEC81B-184
61	VEC81B-193
62	GBR79A-195b
63	VEC81B-202
64	VEC81B-217
65	GBR83A-8
66	GBR83A-10
67	GBR83A-12
68	GBR83A-14a
69	GBR83A-14b
70	GBR83A-16
71	GBR83A-19
72	GBR83A-21
73	GBR83A-22a
74	GBR83A-22b
75	GBR83A-23
76	GBR83A-26
77	PAR83A-6
78	GBR84A-89
79	GBR84A-103
80	GBR84A-182
81	GBR84A-185
82	GBR84A-188
83	GBR84A-195
84	GBR85A-22
85	GBR85A-25
86	GBR85A-28
87	GBR85A-31

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
GASTROPODS																			
Puncturella cucullata	0	0	0	2	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Puncturella galeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Puncturella multistriata	0	0	1	3	0	2	0	0	0	1	0	0	0	1	0	0	0	1	0
Diodora aspera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Margarites pupillus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solariella obscura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma annulatum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma ligatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma variegatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Tegula pulligo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halistylus pupoides	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Homalopoma luridum	0	0	1	2	0	1	0	0	0	0	0	0	2	2	0	0	2	1	0
Lottia pelta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acmaea mitra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tectura persona	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Lepeta caeca	0	0	0	0	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Petaloconchus compactus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bittium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitidiscala sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eulima sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichotropis cancellata	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calyptraea fastigiata	0	0	0	2	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1
Crepidula dorsata	0	1	1	2	3	0	4	0	0	0	0	0	0	1	0	0	0	0	2
Crepidula nummaria	0	0	0	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Polinices pallidus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natica clausa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nucella canaliculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Nucella emarginata	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Nucella lamellosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ocenebra interfossa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocenebra lurida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocenebra triangulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratostoma foliatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trophonopsis pacificus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trophonopsis lasius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alia gausapata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Amphissa columbiana	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1
Searlesia dira	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Nassarius mendicus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olivella baetica	2	2	3	1	0	3	0	1	2	5	0	1	0	0	2	1	1	0	2
Antiplanes perversa	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antiplanes thalea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mitromorpha gracilior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cylichnella culcitella	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclichna attonsa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES

BIVALVES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Acila castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuculana penderi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycymeris subobsoleta	1	6	4	6	0	6	1	2	2	2	6	4	6	6	4	2	4	3	4
Crenella decussata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chlamys hastata	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Chlamys rubida	0	0	3	1	1	0	1	0	0	0	0	3	1	0	1	0	1	0	2
Chlamys sp.	0	1	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Pododesmus cepio	1	2	1	3	0	2	0	2	3	2	2	1	0	0	1	1	1	0	2
Diplodonta orbella	0	0	1	2	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Miodontiscus prolongatus	0	3	1	2	0	3	0	0	1	0	2	3	0	1	2	0	0	1	0
Cyclocardia crassidens	0	0	3	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0
Cyclocardia crebicostrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclocardia ventricosa	0	3	0	3	4	2	0	0	0	0	1	0	0	1	0	0	0	0	0
Tridonta alaskensis	0	2	1	0	1	0	0	0	0	0	3	1	1	1	0	0	0	1	0
Astarte equimaulti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nemocardium centifilosum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serripes groenlandicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium californiense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium ciliatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium fucanum	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium nuttalii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spisula falcata	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Tellina bodegensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tellina nucleoides	3	0	3	1	0	3	0	5	5	4	0	1	0	0	1	4	0	0	0
Macoma carlottensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gari californica	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semele rubropicta	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Protothaca staminea	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Humilaria kennerlyi	0	1	1	3	0	1	0	0	0	0	0	0	1	1	1	0	1	0	1
Psephidia lordi	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saxidomus giganteus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hiatella arctica	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Panope abrupta	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Pandora bilirata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora filosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Pandora wardiana	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Pandora sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
GASTROPODS																			
Puncturella cucullata	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Puncturella galeata	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
Puncturella multistriata	1	1	0	2	0	0	1	0	0	0	0	0	2	0	1	2	0	0	0
Diodora aspera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Margarites pupillus	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0
Solariella obscura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma annulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Calliostoma ligatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma variegatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tegula pulligo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halistylus pupoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Homalopoma luridum	2	1	0	2	0	0	0	0	0	0	0	0	3	1	1	2	0	0	0
Lottia pelta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Acmaea mitra	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tectura persona	1	1	0	3	0	0	1	0	0	0	0	0	1	1	2	1	0	0	0
Lepeta caeca	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petaloconchus compactus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Bittium sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Nitidiscala sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Eulima sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichotropis cancellata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calyptraea fastigiata	1	3	0	1	0	0	1	0	0	0	0	1	2	0	4	2	0	0	0
Crepidula dorsata	1	2	0	0	0	0	1	0	0	1	0	0	2	1	1	2	0	0	0
Crepidula nummaria	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polinices pallidus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Natica clausa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nucella canaliculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nucella emarginata	0	1	0	0	0	1	0	1	1	0	0	0	2	1	4	2	0	0	0
Nucella lamellosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Ocenebra interfossa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Ocenebra lurida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocenebra triangulata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ceratostoma foliatum	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Trophonopsis pacificus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trophonopsis lasius	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Alia gausapata	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0
Amphissa columbiana	3	0	0	2	0	0	0	0	0	1	0	0	3	2	2	1	4	1	0
Searlesia dira	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nassarius mendicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olivella baetica	0	0	0	1	1	1	0	3	3	0	0	2	0	0	0	1	0	3	0
Antiplanes perversa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antiplanes thalea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mitromorpha gracilior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cylichnella culcitella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Cyclichna attonsa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES

BIVALVES

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Acila castrensis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuculana penderi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycymeris subobsoleta	5	6	0	6	3	3	3	4	5	0	0	5	6	4	4	0	0	4	6
Crenella decussata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chlamys hastata	1	1	0	1	1	0	1	1	0	2	0	0	2	0	0	0	0	0	0
Chlamys rubida	1	0	1	2	0	0	0	2	0	3	0	0	1	1	2	0	4	0	0
Chlamys sp.	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pododesmus cepio	0	2	0	2	2	3	3	3	0	0	0	0	3	1	2	0	0	0	0
Diplodonta orbella	0	2	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0
Miodontiscus prolongatus	2	1	0	2	0	0	0	0	0	0	0	0	1	1	1	0	1	2	0
Cyclocardia crassidens	0	0	0	1	0	0	0	0	0	0	0	0	3	0	1	0	0	1	0
Cyclocardia crebicostrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclocardia ventricosa	0	0	0	2	0	0	0	0	0	2	0	0	3	0	0	0	4	1	0
Tridonta alaskensis	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	2	0
Astarte equimaulti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Nemocardium centifilosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serripes groenlandicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Clinocardium californiense	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium ciliatum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium fucanum	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium nuttalii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spisula falcata	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Tellina bodegensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tellina nucleoides	1	1	0	0	6	5	3	4	4	0	0	4	0	0	0	0	0	1	0
Macoma carlottensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Gari californica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semele rubropicta	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Protothaca staminea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Humilaria kennerlyi	1	2	0	2	0	1	0	0	1	0	0	0	2	2	2	0	0	0	0
Psephidia lordi	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	4	0	0
Saxidomus giganteus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hiatella arctica	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Panope abrupta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora bilirata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Pandora filosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora wardiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

SPECIES	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
GASTROPODS																			
Puncturella cucullata	2	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2	0	1
Puncturella galeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Puncturella multistriata	0	0	0	1	0	0	0	1	1	0	1	1	0	0	1	0	1	1	0
Diodora aspera	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0
Margarites pupillus	2	0	0	1	0	0	0	0	0	3	3	1	0	0	1	2	3	1	0
Solariella obscura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma annulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Calliostoma ligatum	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	1	0	0
Calliostoma variegatum	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Calliostoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tegula pulligo	0	0	0	1	0	1	0	2	0	0	3	0	0	0	0	0	1	1	1
Halistylus pupoides	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Homalopoma luridum	2	0	0	2	1	0	3	4	1	3	4	3	0	0	3	3	3	4	4
Lottia pelta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acmaea mitra	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	3	0	0
Tectura persona	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0
Lepeta caeca	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Petaloconchus compactus	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Bittium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitidiscala sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Eulima sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichotropis cancellata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Calyptraea fastigiata	0	0	0	1	2	2	1	0	2	2	2	2	0	1	0	1	3	2	1
Crepidula dorsata	3	3	0	2	2	3	1	2	2	3	3	3	0	0	0	2	3	0	1
Crepidula nummaria	0	2	0	1	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Polinices pallidus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natica clausa	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Nucella canaliculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nucella emarginata	0	0	0	3	0	0	2	2	1	2	1	2	0	0	1	0	2	0	2
Nucella lamellosa	0	1	1	0	2	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Ocenebra interfossa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocenebra lurida	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocenebra triangulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratostoma foliatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trophonopsis pacificus	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2	1	0
Trophonopsis lasius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alia gausapata	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Amphissa columbiana	1	2	0	0	0	0	0	1	2	1	1	2	0	3	0	1	1	0	0
Searlesia dira	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Nassarius mendicus	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Olivella baetica	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Antiplanes perversa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antiplanes thalea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mitromorpha gracilior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cylichnella culcitella	0	0	0	0	0	0	0	1	0	2	0	0	0	0	1	0	0	1	0
Cyclichna attonsa	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES

BIVALVES

	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Acila castrensis	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
Nuculana penderi	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Glycymeris subobsoleta	3	6	0	5	6	5	5	5	6	4	5	5	0	0	5	5	5	5	5
Crenella decussata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Chlamys hastata	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	1	0	0
Chlamys rubida	2	1	0	0	1	0	0	0	3	0	1	2	1	1	1	0	1	0	0
Chlamys sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pododesmus cepio	1	0	0	3	0	3	2	2	2	2	1	0	0	0	0	0	3	1	1
Diplodonta orbella	2	0	0	0	0	0	0	0	2	1	0	1	0	0	2	0	3	0	1
Miodontiscus prolongatus	1	4	0	0	0	2	1	2	2	3	2	3	0	0	3	3	2	3	2
Cyclocardia crassidens	0	1	0	0	0	0	0	0	1	0	0	2	0	0	1	0	2	0	1
Cyclocardia crebicostrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclocardia ventricosa	0	1	0	0	0	0	0	0	1	0	0	0	3	2	2	1	0	3	0
Tridonta alaskensis	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0	0	1	0
Astarte equimaulti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nemocardium centifilosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serripes groenlandicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium californiense	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Clinocardium ciliatum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium fucanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium nuttalii	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spisula falcata	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Tellina bodegensis	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Tellina nucleoides	0	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Macoma carlottensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gari californica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semele rubropicta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protothaca staminea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humilaria kennerlyi	0	0	0	1	0	3	3	3	4	3	2	1	0	0	2	0	4	3	3
Psephidia lordi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saxidomus giganteus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hiatella arctica	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0
Panope abrupta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora bilirata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora filosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora wardiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
GASTROPODS																			
Puncturella cucullata	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Puncturella galeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Puncturella multistriata	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Diodora aspera	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Margarites pupillus	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Solariella obscura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Calliostoma annulatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma ligatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Calliostoma variegatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tegula pulligo	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halistylus pupoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Homalopoma luridum	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0
Lottia pelta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acmaea mitra	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Tectura persona	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepeta caeca	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	1	1
Petaloconchus compactus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bittium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitidiscala sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eulima sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Trichotropis cancellata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calyptraea fastigiata	2	1	2	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0
Crepidula dorsata	2	3	2	0	0	0	0	0	0	0	3	4	2	0	3	1	3	2	0
Crepidula nummaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	1	3	0
Polinices pallidus	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Natica clausa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nucella canaliculata	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Nucella emarginata	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Nucella lamellosa	0	2	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	1	1
Ocenebra interfossa	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocenebra lurida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocenebra triangulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratostoma foliatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trophonopsis pacificus	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0
Trophonopsis lasius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alia gausapata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphissa columbiana	1	1	0	0	0	0	1	0	0	0	0	2	1	0	0	0	1	0	0
Searlesia dira	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Nassarius mendicus	0	0	0	0	1	0	0	0	0	2	2	4	0	0	0	0	1	1	0
Olivella baetica	0	0	0	0	4	1	2	0	0	0	0	0	2	2	1	0	0	0	0
Antiplanes perversa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antiplanes thalea	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Mitromorpha gracilior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cylichnella culcitella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclichna attonsa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES

BIVALVES

	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Acila castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuculana penderi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycymeris subobsoleta	5	5	5	4	4	5	5	3	3	4	0	4	0	0	6	4	5	6
Crenella decussata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chlamys hastata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chlamys rubida	0	0	0	3	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Chlamys sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pododesmus cepio	0	2	1	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Diplodonta orbella	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miodontiscus prolongatus	1	3	3	0	0	1	0	0	0	0	0	0	0	0	0	2	1	2
Cyclocardia crassidens	1	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cyclocardia crebicostrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclocardia ventricosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Tridonta alaskensis	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Astarte equimaulti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nemocardium centifilosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serripes groenlandicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium californiense	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0
Clinocardium ciliatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium fucanum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium nuttalii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spisula falcata	0	0	0	0	1	0	0	2	0	0	0	2	0	2	0	0	0	0
Tellina bodegensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tellina nucleoides	0	0	0	5	4	0	1	6	0	3	3	3	0	0	0	0	0	2
Macoma carlottensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macoma sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Gari californica	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Semele rubropicta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protothaca staminea	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0
Humilaria kennerlyi	2	1	3	0	0	0	1	1	0	0	0	3	0	0	0	0	0	0
Psephidia lordi	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Saxidomus giganteus	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Hiatella arctica	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Panope abrupta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora bilirata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora filosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora wardiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pandora sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES	77	78	79	80	81	82	83	84	85	86	87
GASTROPODS											
Puncturella cucullata	0	0	0	0	0	0	0	0	0	0	0
Puncturella galeata	0	0	0	0	0	0	0	0	0	0	0
Puncturella multistriata	0	0	0	0	0	0	0	0	0	0	0
Diodora aspera	0	0	0	0	0	0	0	0	0	0	0
Margarites pupillus	0	0	0	0	1	0	0	0	0	0	0
Solariella obscura	2	0	0	0	0	0	0	0	0	0	0
Calliostoma annulatum	0	0	0	0	0	0	0	0	0	0	0
Calliostoma ligatum	0	0	0	0	0	0	0	0	0	0	0
Calliostoma variegatum	0	0	0	0	0	0	0	0	0	0	0
Calliostoma sp.	0	0	0	0	0	0	0	0	0	0	0
Tegula pulligo	0	0	0	0	0	0	0	0	0	0	0
Halistylus pupoides	0	0	0	0	0	0	0	0	0	0	0
Homalopoma luridum	0	0	0	0	0	0	0	0	0	0	0
Lottia pelta	0	0	0	0	0	0	0	0	0	0	0
Acmaea mitra	0	0	0	0	0	0	0	0	0	0	0
Tectura persona	0	0	0	0	0	0	0	0	0	0	0
Lepeta caeca	0	2	0	0	0	0	0	0	0	1	0
Petaloconchus compactus	0	0	0	0	0	0	0	0	0	0	0
Bittium sp.	0	0	0	0	0	0	0	0	0	0	0
Nitidiscala sp.	0	0	0	0	0	0	0	0	0	0	0
Eulima sp.	0	0	0	0	0	0	0	0	0	0	0
Trichotropis cancellata	0	0	0	0	0	0	0	0	0	0	0
Calyptraea fastigiata	1	0	0	0	0	0	0	1	0	0	0
Crepidula dorsata	0	0	0	0	0	0	0	0	0	0	0
Crepidula nummaria	1	0	0	0	0	0	0	0	0	1	0
Polinices pallidus	0	0	0	0	0	0	0	0	0	0	0
Natica clausa	0	1	0	0	0	0	0	0	0	0	0
Nucella canaliculata	0	0	0	0	0	0	0	0	0	0	0
Nucella emarginata	0	0	0	0	0	0	0	0	0	0	0
Nucella lamellosa	2	0	0	0	0	0	0	0	0	3	1
Ocenebra interfossa	0	0	0	0	0	0	0	0	0	0	0
Ocenebra lurida	0	0	0	0	0	0	0	0	0	0	0
Ocenebra triangulata	0	0	0	0	0	0	0	0	0	0	0
Ceratostoma foliatum	0	0	0	0	0	0	0	0	0	0	0
Trophonopsis pacificus	0	0	0	0	0	0	0	0	0	0	0
Trophonopsis lasius	0	0	0	0	0	0	0	0	0	0	0
Alia gausapata	0	0	0	0	0	0	0	0	0	0	0
Amphissa columbiana	2	0	0	2	0	1	0	0	0	0	0
Searlesia dira	0	0	0	0	0	0	0	0	0	0	0
Nassarius mendicus	0	0	0	0	0	0	0	0	0	0	1
Olivella baetica	0	0	0	1	0	0	0	0	0	0	2
Antiplanes perversa	0	0	0	0	0	0	0	0	0	0	0
Antiplanes thalea	0	0	0	0	0	0	0	0	0	0	0
Mitromorpha gracilior	0	0	0	0	0	0	0	0	0	0	0
Cylichnella culcitella	0	0	0	0	0	0	0	0	0	0	0
Cyclichna attonsa	0	0	0	0	0	0	0	0	0	0	0

SPECIES

BIVALVES

	77	78	79	80	81	82	83	84	85	86	87
Acila castrensis	0	0	0	0	0	0	0	0	0	0	0
Nuculana penderi	0	0	0	0	0	0	0	0	0	0	0
Glycymeris subobsoleta	6	0	2	0	0	0	0	0	1	4	2
Crenella decussata	0	0	0	0	0	0	0	0	0	0	0
Chlamys hastata	0	0	0	0	0	0	0	0	0	0	0
Chlamys rubida	0	0	0	0	0	2	0	0	0	0	0
Chlamys sp.	0	0	0	0	0	0	0	0	0	0	0
Pododesmus cepio	0	0	0	0	0	0	0	0	0	0	0
Diplodonta orbella	0	0	0	0	0	0	0	0	0	0	0
Miodontiscus prolongatus	0	0	0	0	0	0	0	0	0	0	0
Cyclocardia crassidens	0	0	0	0	0	0	0	0	0	0	0
Cyclocardia crebicostrata	0	1	0	0	0	0	0	0	0	0	0
Cyclocardia ventricosa	0	0	0	3	0	2	0	0	0	0	0
Tridonta alaskensis	0	0	0	2	0	0	0	0	0	0	0
Astarte equimaulti	0	0	0	0	0	0	0	0	0	0	0
Nemocardium centifilosum	0	0	0	0	0	0	0	0	0	0	0
Serripes groenlandicus	0	0	0	0	0	0	0	0	0	0	0
Clinocardium californiense	0	0	0	2	3	0	0	0	0	1	1
Clinocardium ciliatum	0	0	0	0	0	0	0	0	0	0	0
Clinocardium fucanum	0	0	0	0	0	0	0	0	0	0	0
Clinocardium nuttalii	0	0	0	0	0	0	0	0	0	0	1
Spisula falcata	0	0	0	0	0	0	0	0	0	1	2
Tellina bodegensis	0	0	0	0	0	0	0	0	0	0	0
Tellina nucleoides	2	0	6	0	0	0	4	6	4	6	6
Macoma carlottensis	0	0	0	0	2	0	0	0	0	0	0
Macoma sp.	0	0	0	0	0	0	0	0	0	0	2
Gari californica	0	0	0	0	0	0	0	0	0	0	0
Semele rubropicta	0	0	0	0	0	0	0	0	0	0	1
Protothaca staminea	1	0	0	0	0	0	0	0	0	2	0
Humilaria kennerlyi	0	0	0	0	0	0	0	0	0	0	1
Psephidia lordi	0	0	0	0	0	0	0	1	1	0	0
Saxidomus giganteus	0	0	0	0	0	0	0	0	0	0	1
Hiatella arctica	0	0	0	0	0	0	0	0	0	0	0
Panope abrupta	0	0	0	0	0	0	0	0	0	0	0
Pandora bilirata	0	0	0	0	0	0	0	0	0	0	0
Pandora filosa	0	0	0	0	0	0	0	0	0	0	0
Pandora wardiana	0	0	0	0	0	0	0	0	0	0	0
Pandora sp.	0	0	0	0	0	0	0	0	0	0	0

3. Habitats of Fauna

The following tables give an indication of the water depths and substrates in which the organisms normally live.

Depth

As estimates of depth preferences for species vary widely with the source, the estimates from three sources are given. Part of the variation between them may be explained by the different areas upon which the data is based; Bernard (1970) is based on British Columbia data, while Abbott (1974) is based on data from Alaska to the Gulf of California. Some species which are intertidal in Alaska are found in deep water in California (Bernard, 1970). Three columns are given for water depth in metres, the first from estimates from Bernard (1970), the second from Abbott (1974) and the third from Kozloff (1987). The following abbreviations are used: sh - shallow, iT - intertidal, sT - subtidal, lit - littoral, off - offshore, v - very, D - deep.

If no estimate was given in that work, that column is blank.

Substrate

As the substrate preferences given in the literature were less varied than the water depths, only one column is used. The primary source used for this data is Nelson and Bornhold (1983). For species not listed by them, Kozloff (1987) and Abbott (1974) were consulted. Finally, if these contained no substrate information, but the genus was listed by Keen

(1963), the substrate preference of the genus was listed. The following abbreviations are used: R - rock, G - gravel, S - sand, and M - mud.

Shallowness Class

Species found in Hecate Strait are classified as shallower than 50 m (S), deeper than 50 m (D) or found both above and below 50m (I). The depth ranges from Bernard (1970) are used for this determination, because his data was wholly from British Columbia. However, in a few cases where the Bernard (1970) estimates appeared too conservative, Abbott (1974) was used. In many cases, shells were found in the study area at depths which exceeded those listed by Bernard (1970), although they rarely exceeded those of Abbott (1974).

Substrate Class

Species from Hecate Strait were described as mud or sand dwelling (S), rock or gravel dwelling (H) or able to live in either sand or gravel (I).

SPECIES	DEPTH			SUBSTRATE	SHALLOWNESS CLASS	SUBSTRATE CLASS
	Bernard	Abbott	Kozloff			
Puncturella cucullata	sT-100	sT-135		R	I	H
Puncturella galeata	sT-50	20-135		R	S	H
Puncturella multistriata	iT-100			R	I	H
Diodora aspera	iT	iT-35		R	S	H
Spiromoelleria quadrae	sT-30	iT-off			S	
Homalapoma luridum	sT-50	sh		R	S	H
Margarites pupillus	iT-5	lit		R/G	S	H
Margarites marginatus	20-100	2-135	iT-sh sT			
Lirularia lirulata	iT-20		iT-sh sT			
Solariella obscura	50-200	5-700			D	
Solariella permabilis	15-100	35-600				
Calliostoma annulatum	iT-20	off		R/G	S	H
Calliostoma ligatum	sT-250	lit.		R/G	I	
Calliostoma variegatum	iT-200	25-700		R/G	I	H
Cidarina cidaris	35-600	50-300	sh sT			
Tegula pulligo	iT-10			R/G	S	H
Lottia pelta	iT			R	S	H
Halistylus pupoides	10-50	15-70	sh sT	S/G	S	I
Acmaea mitra	iT-20	sT	iT-sT	R/G	S	H
Tectura persona	iT	iT	iT	R	S	H
Lepeta caeca	sT-200	5-350			I	
Barleeia haliotiphila	10-50	iT-25		R	S	H
Tachyrhynchus lacteolus	iT-100	25-30			I	
Micranellum crebricinctum	sT-100				I	
Petaloconchus compactus	iT	sT-90		R/G	S	H
Bittium eschritii	iT-100					
Bittium attenuatum	iT-10	off-65			S	
Cerithiopsis stejnegeri						
Cerithiopsis truncatum	100-200					
Trichotropis cancellata	sT-50	sh	sh sT		S	
Calyptraea fastigiata	iT-100	20-135			I	
Crepidula dorsata	iT-40			R/G	S	H
Crepidula nummaria	iT-5			R/G	S	H
Polinices pallidus	20-200			S	I	S
Natica clausa	50-200	mod. D	sT		D	
Nitidiscala indianorum	iT-50	sh sT	iT-sT	G	S	H
Epitonium greenlandicum	100-300	20-225			D	
Opalia borealis	sT-100	off-90	iT-sT		I	
Eulima micans	iT-20	2-55			S	
Sabinella ptilocrinicola			deep		D	
Nucella canaliculata	iT				S	
Nucella emarginata	iT			R	S	H
Nucella lamellosa	iT-15			R	S	H
Ocenebra interfossa	iT	sT-10		R	S	H
Ocenebra lurida	iT	sT-55	iT	R	S	H
Ceratostoma foliatum	iT-50	sT-60	iT-sh sT	R	S	H
Trophonopsis pacificus	500-700	iT-v. D			I	
Trophonopsis lasius	iT-150	45-900		G	I	H
Alia gausapata	iT-5	sh	iT-sT		S	
Alia permodesta	600-1200		sT			
Amphissa columbiana	iT-50	sh	iT-sT	R/G	S	H
Searlesia dira	iT	sh	iT-sh sT	R	S	H

SPECIES	DEPTH			SUBSTRATE	SHALLOWNESS CLASS	SUBSTRATE CLASS
	Bernard	Abbott	Kozloff			
Nassarius mendicus	iT-10	sT-50		M or S	S	S
Olivella baetica	sT-30			S	S	S
Granulina margariticula	iT-20	sT-70	iT			
Oenopota crebicostata	iT-30					
Oenopota turricula						
Mitromorpha gracilior						
Antiplanes perversa	50-500				D	
Antiplanes thalea						
Cylichnella culcitella	iT-50	20-280		S	S	S
Cylichna attonsa		sT-2000			I	
Acila castrensis	80-250	5-190		sM	D	S
Nuculana penderi			D		D	
Philobrya setosa	iT-10		iT-sh sT			
Glycymeris subobsoleta	sT-80	sh-70	sT	S/G	I	I
Limatula subauriculata			50-350			
Crenella decussata	40-100	5-270	sT		D	
Hinnites giganteus	sT-30	sT-55		R/G	S	
Chlamys hastata	50-200	sh-35			D	
Chlamys rubida	10-100	sh-1500	sh. sT.		I	
Pododesmus cepio	iT-20	sT-60	iT-sT	R/G	S	H
Lucinoma tennuisculpta	15-100					
Diplodonta orbella	iT-10	shallow		S	S	S
Miodontiscus prolongatus	sT-50	10-50		S/G	S	I
Cyclocardia crassidens	50-200	20-200		S	D	S
Cyclocardia crebicostata	iT-10			S	S	S
Cyclocardia ventricosa	20-200	offshore		S	I	S
Tridonta alaskensis	50-200	20-70	sT	S/G	D	I
Astarte esquimaulti	5-50	20-70	sT		S	
Nemocardium centifilosum	30-180				I	
Serripes groenlandicus	sT-50	5-110			S	
Clinocardium californiense	30-200			S	D	S
Clinocardium ciliatum	60-200	offshore		S	D	S
Clinocardium fucanum				S		S
Clinocardium nuttalii	iT-10	off	iT-sh sT	S	S	S
Spisula falcata	it-5	sT	prim. sT	S	S	S
Tellina bodegensis	iT-10	sT-25		S or M	S	S
Tellina nucleoides	iT-10	sT-60		S	S	S
Macoma carlottensis	15-200				I	
Gari californica	it-10	sT-45		S	S	S
Semele rubropicta	iT-20	35-90		S	S	S
Protothaca staminea	iT			S/G	S	I
Humilaria kennerlyi	iT-50	5-35	sT	S/G	S	I
Psephidia lordi	iT-100		iT-sh sT	S	S	S
Saxidomus giganteus	iT-20		iT	S/M	S	S
Mya truncata						
Hiatella arctica	iT-100			R	I	H
Panope abrupta	iT-20			M	S	S
Pandora bilirata	50-200	35-260		M	D	S
Pandora wardiana	100-400			R	D	H

4. Substrate Index and Shallowness Index

Calculation:

Substrate index is a measure of the relative abundance of rock and gravel fauna (Class H) in a sample, ranging from 0 to 100. It is not a strict percentage. In order to avoid the index being entirely controlled by the dominant species, the abundance number (from 0 to 6) rather than the actual proportions are used in the calculation. As fauna which are tolerant of sand or gravel (Class I) might be expected to increase as the substrate changed from sand to gravel, one half of the sum of the class I fauna is added to sum of the class H fauna:

$$\text{Substrate Index} = \frac{H + \frac{1}{2}I}{H + I + S}$$

Values for shallowness index for Hecate Strait samples are given on the following pages.

Shallowness Index

Shallowness index is essentially the same as substrate index, but measures the prevalence of shallow water (<50m; class S) fauna. Since fauna of "intermediate" water depths (those found in both shallow and deep water; class I) might be expected to increase relative to class D (deep) as the water depth decreased, one half the class I fauna is added to the class S fauna. Thus:

$$\text{Shallowness Index} = \frac{S + \frac{1}{2} I}{S + I + D}$$

	SAMPLE NO.	DEPTH (m)	GRAVEL (%)	% CaCO3 SAND	SUBSTRATE INDEX	SHALLOWNESS INDEX
2	GBR79A-70	47	16.7	3.5	46	71
3	GBR79A-85	53	21.0	52.0	38	77
4	GBR79A-90	59	27.4	49.5	67	74
5	GBR79A-96	55	20.2	15.5	52	61
6	GBR79A-100	62	19.0	87.5	40	77
7	GBR79A-132	44	89.3	22.0	92	79
8	GBR79A-153	29	2.0	28.5	36	86
9	GBR79A-154	31	31.5	13.0	38	84
10	GBR79A-157	57	4.0	62.5	35	82
11	GBR79A-178	48	30.2	42.5	43	54
12	GBR79A-180	55	4.9	16.5	43	85
13	GBR79A-193	57	42.3	45.5	55	64
14	GBR79A-194	55	55.0	65.0	62	64
15	GBR79A-203	55	10.1	40.0	50	81
16	GBR79A-233	33	36.9	28.0	25	88
17	GBR79A-235	29	62.8	32.0	57	83
18	GBR79A-239	44	53.8	49.5	63	62
19	GBR79A-244	31	49.8	21.5	68	82
20	GBR79B-5	40	75.7	66.5	73	77
21	GBR79B-6	44	41.1	78.5	64	71
22	GBR79B-11	81	19.0	3.0	50	40
23	GBR79B-22	55	41.8	65.5	63	73
24	GBR79B-34	30	2.7	9.0	29	83
25	GBR79B-35	29	20.6	21.5	43	89
26	GBR79B-36	33	2.8	17.6	63	76
27	GBR79B-37	35	8.0	21.0	42	81
28	GBR79B-44	46	2.6	9.5	30	80
29	GBR79B-55	55	36.4	5.0	42	62
30	GBR79B-66	128	51.7	3.0		
31	GBR79B-78	40	32.6	15.0	35	73
32	VEC81B-14b	48	51.6	64.6	67	73
33	VEC81B-15	45	71.6	41.5	72	84
34	VEC81B-29	41	65.8	46.5	78	74
35	VEC81B-30	45	26.4	63.0	62	78
36	VEC81B-63	71	72.4	22.5	42	80
37	VEC81B-65	73	3.0	31.0	54	60
38	VEC81B-69	30	57.6	55.0	63	63
39	VEC81B-84	42	71.7	72.0	81	89
40	VEC81B-85	50	72.3	45.5	61	75
41	VEC81B-101	133	83.3	5.0		
42	VEC81B-107	33	63.1	39.0	76	82
43	VEC81B-110	32	76.6	60.5	77	76
44	VEC81B-132	34	33.5	73.0	71	81
45	VEC81B-133	36	26.6	72.0	73	85

SAMPLE NO.	DEPTH (m)	GRAVEL (%)	% CaCO3 SAND	SUBSTRATE INDEX	SHALLOWNESS INDEX
VEC81B-134	36	45.2	63.0	70	86
VEC81B-139	54	89.1	87.5	62	74
VEC81B-148b	30	38.2	72.0	79	79
VEC81B-153	30	38.2	83.5	82	79
VEC81B-156	40	69.3	93.5	71	74
VEC81B-163	145	54.9	16.0	15	35
VEC81B-169	190	79.4	15.5	73	63
VEC81B-171	51	40.8	94.0	61	80
VEC81B-173a	48		92.0	75	80
VEC81B-175	33	52.9	98.0	79	79
VEC81B-176	25	40.9	97.5	62	72
VEC81B-177	28		87.5	68	80
VEC81B-178	28	49.4	95.5	79	76
VEC81B-179	22	72.5	93.5	82	89
VEC81B-184	36		50.5	61	69
VEC81B-193	49	6.7	7.5	43	87
GBR79A-195b	133	0.0	<1.0	20	87
VEC81B-202	50	74.5	49.0	45	59
VEC81B-217	33	41.5	33.5	56	83
GBR83A-8	29	13.7	12.0	21	89
GBR83A-10	24	65.2	17.0		
GBR83A-12	27	1.1	11.5	27	73
GBR83A-14a	29	84.0	33.0	45	82
GBR83A-14b	29	13.9	44.0	50	70
GBR83A-16	31	17.9	6.0	60	100
GBR83A-19	40	45.5	38.0		
GBR83A-21	26	25.2	38.0	68	75
GBR83A-22a	20	20.4	77.5	67	79
GBR83A-22b	20	78.7	81.0	73	76
GBR83A-23	27	62.7	62.5	67	76
GBR83A-26	42	63.7	12.0	55	60
PAR83A-6	35	62.0		63	65
GBR84A-89	59	86.3	12.0		
GBR84A-103	26	12.9	14.5	13	88
GBR84A-182	135	4.8	7.5	20	35
GBR84A-185	132	11.0	<2.0	17	50
GBR84A-188	117	27.9	4.0	40	80
GBR84A-195	145	8.4	<2.0		
GBR85A-22	25	1.1	8.5	13	88
GBR85A-25	29	1.8	12.0	8	83
GBR85A-28	26	65.7	27.5	42	76
GBR85A-31	29	16.6	12.5	12	86

5. Cluster Analysis

Because the absence of a particular species in two samples cannot generally be regarded as a significant similarity, the distance coefficient used to analyse the pebble lithologies was unsuitable. The carbonate content in the sediment appeared to be related to the distribution of the most common species. Therefore, it was decided that a coefficient which recognized differences in quantity, rather than merely the presence or absence of a species, was necessary. The one chosen was that of Kulczynski (1928), which is regarded as a good coefficient for normalized ecological data, such as this set (Legendre and Legendre, 1983).

The coefficient is calculated by matching the quantity of species in two samples. Similarities add to the numerator and the denominator, dissimilarities add only to the denominator. For example, if one of the samples contained a relative abundance of 3 of a species, and in the other the abundance of 5, the similarity (A) would add 3 to the numerator, while the extra 2 in the second sample would be added to the denominator. The quantities B and C are defined as the unmatched components in each sample respectively.

e.g.	Sample 1	Sample 2
Species 1	2	4
Species 2	0	3
Species 3	5	1

In the example above, the A quantity is 2 + 0 + 1 = 3, the B quantity is 0 + 0 + 4 = 4 and the C quantity is 2 + 3 + 0 = 5. The Kulczynski similarity coefficient is one half the square root of the following equation:

$$\frac{2A}{A + B} * \frac{2A}{A + C}$$

For the example given above this becomes one half the square root of 6/7 * 6/8, which is approximately 0.4. The similarity coefficients obtained can range from 0 (no similarity) to 1 (identical).

After the similarity matrix was calculated, the data was clustered using a BASIC program, just as described in Appendix B.2.

6. Raw Data - Cook Bank

Taxonomic problems and the nomenclature used in this study are described in Appendix A.1. All data is from Lee & Adkins (1979). Relative abundance data was on a slightly different scale, from 0 to 5, than that used for Hecate Strait; results are not strictly comparable.

< 5% present (1) ; 5-10% scarce (2); 10-25% common (3); 25-50% abundant (4); 50-100% very abundant (5)

The table below gives the faunal sample designations used in the following faunal abundance tables, together with their Geological Survey of Canada sample number:

1. PAR76-96
2. PAR76-108
3. PAR76-110
4. PAR76-123
5. PAR76-153
6. PAN77-2
7. PAN77-28
8. PAN77-38
9. PAN77-39
10. PAN77-117
11. PAN78-1
12. PAN78-3
13. PAN78-4
14. PAN78-6
15. PAN78-7
16. PAN78-8
17. PAN78-10
18. PAN78-65
19. PAN78-66
20. PAN78-67
21. PAN78-68
22. PAN78-68
23. PAN78-69
24. PAN78-70
25. PAN78-71
26. PAN78-72
27. PAN78-74
28. PAN78-75
29. PAN78-76b
30. PAN78-79
31. PAN78-80
32. PAN78-81
33. PAN78-82
34. PAN78-85
35. PAN78-86
36. PAN78-87
37. PAN78-88
38. PAN78-89
39. PAN78-90
40. PAN78-90b
41. PAN78-91
42. PAN78-93b
43. PAN78-100
44. PAN78-102
45. PAN78-104
46. PAN78-108
47. PAN77-117
48. PAN77-118
49. PAN77-119
50. PAN77-120
51. PAN77-121

SPECIES

GASTROPODS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Puncturella cucullata	0	1	0	0	1	2	2	1	0	0	2	2	2	0	0	2	2	0	0
Puncturella multistriata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diodora aspera	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Spiromoelleria quadrae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Homalapoma luridum	2	2	1	2	0	2	2	1	0	0	2	2	2	1	2	1	2	0	0
Margarites pupillus	0	0	0	2	0	2	2	2	0	0	1	2	0	2	2	2	2	2	0
Margarites marginatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lirularia lirulata	0	0	0	2	1	0	0	0	0	0	2	2	2	0	0	0	2	0	0
Solariella permabilis	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma annulatum	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0
Calliostoma ligatum	0	0	0	2	0	2	0	0	0	0	0	0	2	0	0	0	0	2	0
Calliostoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Cidarina cidaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Tegula pulligo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halistylus pupoides	2	2	1	0	1	0	2	0	0	0	0	1	0	0	2	0	2	1	0
Acmaea mitra	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Tectura persona	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0
Lepeta caeca	1	[illegible]	0	1	2	0	0	0	0	0	0	0	0	2	0	2	2	0	0
Barleeia haliotiphila	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Tachyrhynchus lacteolus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micranellum crebricinctum	2	2	0	0	2	2	0	0	0	0	0	2	0	0	0	2	2	0	0
Petalochus compactus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bittium eschritii	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0
Bittium attenuatum	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	0	2
Bittium sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cerithiopsis stejnegeri	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cerithiopsis truncatum	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0
Cerithiopsis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichotropis cancellata	0	0	0	0	0	2	2	0	0	0	0	0	2	0	0	1	2	0	0
Calyptraea fastigiata	0	1	0	0	0	0	0	0	0	0	0	1	0	2	0	1	2	2	0
Crepidula dorsata	0	0	0	0	0	0	2	0	0	0	2	0	1	0	0	0	1	0	0
Crepidula nummaria	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Natica clausa	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitidiscala indianorum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Nitidiscala sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Epitonium greenlandicum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opalia borealis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Eulima micans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sabinella ptilocrinicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nucella emarginata	0	0	1	1	1	0	0	0	0	0	0	0	2	0	2	0	0	2	0
Ocenebra interfossa	2	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Trophonopsis pacificus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trophonopsis lasius	0	0	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0
Alia gausapata	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Alia permodesta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphissa columbiana	2	2	0	2	0	2	2	2	0	0	2	2	2	2	2	2	2	2	0

SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Searlesia dira	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Nassarius mendicus	0	0	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0
Olivella baetica	0	1	0	0	0	1	2	0	2	0	0	1	0	0	0	0	0	0	2
Granulina margariticula	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Oenopota crebicostata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Oenopota turricula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mitromorpha gracilior	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mitromorpha sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Turbonilla sp.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Odostomia sp.	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	1	0	0
Cylichnella culcitella	0	0	0	0	0	2	0	0	0	0	0	1	0	1	0	0	0	0	0
Cylichna attonsa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BIVALVES																			
Acila castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuculana sp.	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0
Philobrya setosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycymeris subobsoleta	3	4	3	2	3	2	3	2	2	4	3	3	2	1	3	3	4	5	4
Limatula subauriculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crenella decussata	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Hinnites giganteus	0	0	0	0	0	2	2	0	0	0	2	2	2	1	1	2	2	2	0
Chlamys hastata	0	0	0	0	0	2	2	0	0	1	0	0	1	0	0	2	0	0	0
Chlamys rubida	0	1	2	0	2	0	3	0	0	2	2	0	0	1	0	3	3	0	0
Pododesmus cepio	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0
Lucinoma tennuisculpta	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Diplodonta orbella	0	0	0	0	1	2	1	0	0	0	0	2	0	1	0	1	2	0	2
Miodontiscus prolongatus	2	2	2	0	2	0	2	1	0	0	2	2	2	2	2	0	2	2	0
Cyclocardia crassidens	0	2	0	0	1	0	1	0	0	2	2	2	0	2	2	1	0	2	0
Cyclocardia ventricosa	0	2	0	0	0	2	1	0	0	0	0	2	0	2	0	0	0	2	1
Tridonta alaskensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
Nemocardium centifilosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium californiense	0	0	2	0	0	2	1	0	0	0	0	0	0	0	0	1	2	0	1
Clinocardium ciliatum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spisula falcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tellina nucleoides	0	1	0	0	2	0	0	0	1	1	0	0	0	0	2	0	0	0	0
Macoma sp.	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Gari californica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semele rubropicta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Protothaca staminea	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Humilaria kennerlyi	1	1	3	2	1	0	1	2	0	3	4	2	2	2	2	2	2	2	0
Psephidia lordi	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	2	0	0	0
Thracia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mya truncata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Hiatella arctica	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	1	2	0	0
Pandora bilirata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
Pandora wardiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poromya sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES

GASTROPODS	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Puncturella cucullata	0	0	0	2	1	1	0	2	0	0	1	0	2	1	2	2	0	0	0
Puncturella multistriata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Diodora aspera	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spiromoelleria quadrae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Homalapoma luridum	2	0	2	2	2	2	1	0	2	0	0	0	2	0	2	2	0	0	0
Margarites pupillus	2	0	0	2	2	0	0	2	2	1	0	0	0	0	0	2	0	0	0
Margarites marginatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lirularia lirulata	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0
Solariella permabilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma annulatum	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0
Calliostoma ligatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calliostoma sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Cidarina cidaris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tegula pulligo	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Halistylus pupoides	2	2	2	0	2	2	0	2	2	2	2	0	0	2	2	2	2	0	1
Acmaea mitra	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Tectura persona	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepeta caeca	0	0	0	0	0	0	1	2	0	0	0	0	0	2	0	0	0	0	0
Barleeia haliotiphila	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Tachyrhynchus lacteolus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Micranellum crebricinctum	2	2	2	2	2	2	0	1	1	2	2	0	2	2	0	2	0	2	0
Petalochus compactus	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Bittium eschritii	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bittium attenuatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bittium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cerithiopsis stejnegeri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cerithiopsis truncatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cerithiopsis sp.	0	0	0	0	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Trichotropis cancellata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Calyptraea fastigiata	2	0	0	2	0	0	0	2	0	0	0	0	2	0	2	2	0	0	0
Crepidula dorsata	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Crepidula nummaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natica clausa	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitidiscala indianorum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Nitidiscala sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Epitonium greenlandicum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opalia borealis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eulima micans	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0
Sabinella ptilocrinicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nucella emarginata	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Ocenebra interfossa	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0
Trophonopsis pacificus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trophonopsis lasius	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alia gausapata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alia permodesta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphissa columbiana	2	0	0	2	2	2	2	2	2	0	1	0	2	2	2	2	0	2	2

SPECIES	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Searlesia dira	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Nassarius mendicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Olivella baetica	2	1	0	2	2	0	0	0	2	2	2	2	2	1	2	0	0	0	0
Granulina margariticula	0	0	0	0	0	2	0	0	1	0	0	0	0	1	0	0	0	0	0
Oenopota crebicostata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oenopota turricula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mitromorpha gracilior	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Mitromorpha sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Turbonilla sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odostomia sp.	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Cylichnella culcitella	0	0	0	2	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0
Cylichna attonsa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BIVALVES																			
Acila castrensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuculana sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philobrya setosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycymeris subobsoleta	3	3	4	3	3	3	3	2	3	3	2	5	3	2	3	4	3	2	2
Limatula subauriculata	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Crenella decussata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hinnites giganteus	1	0	0	2	2	2	2	0	2	0	0	1	0	0	1	1	2	2	0
Chlamys hastata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
Chlamys rubida	1	0	1	0	1	0	1	0	0	2	2	0	2	0	0	0	0	2	1
Pododesmus cepio	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lucinoma tennuisculpta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diplodonta orbella	2	1	2	2	0	1	0	2	0	0	0	0	0	2	2	2	0	1	1
Miodontiscus prolongatus	2	0	0	2	2	2	2	2	2	0	0	2	2	2	2	2	2	2	1
Cyclocardia crassidens	2	0	2	0	0	0	2	2	0	0	0	0	0	2	2	2	0	1	1
Cyclocardia ventricosa	0	2	2	1	0	1	2	2	0	0	0	2	2	0	1	2	0	0	0
Tridonta alaskensis	1	2	2	0	0	0	0	0	0	0	0	0	1	0	2	1	0	0	0
Nemocardium centifilosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clinocardium californiense	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0
Clinocardium ciliatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spisula falcata	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Tellina nucleoides	2	1	2	2	0	0	0	0	0	3	2	3	2	2	2	0	2	0	1
Macoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gari californica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semele rubropicta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Protothaca staminea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Humilaria kennerlyi	2	1	0	2	2	2	0	2	2	1	0	0	2	0	1	0	2	1	0
Psephidia lordi	2	0	0	0	0	1	0	2	0	0	0	0	2	2	0	0	2	2	2
Thracia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mya truncata	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hiatella arctica	0	0	0	0	2	0	0	2	0	1	0	0	0	0	0	0	0	0	0
Pandora bilirata	1	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0
Pandora wardiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poromya sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SPECIES

GASTROPODS	39	40	41	42	43	44	45	46	47	48	49	50	51
Puncturella cucullata	0	0	0	1	0	0	0	1	2	0	1	0	0
Puncturella multistriata	2	1	0	0	0	0	0	1	1	0	0	0	0
Diodora aspera	1	1	1	0	0	0	0	0	1	0	0	0	0
Spiromoelleria quadrae	0	0	0	0	0	0	0	0	1	0	0	0	0
Homalapoma luridum	2	2	2	0	2	1	0	0	2	0	2	2	2
Margarites pupillus	2	2	2	2	2	0	0	2	2	0	2	2	2
Margarites marginatus	2	0	0	0	0	0	0	0	0	0	0	0	0
Lirularia lirulata	0	0	0	0	2	0	0	0	0	0	0	2	0
Solariella permabilis	0	0	0	0	3	1	2	1	0	3	0	0	0
Calliostoma annulatum	1	0	0	0	0	0	0	0	2	0	0	0	2
Calliostoma ligatum	0	0	0	0	0	0	0	0	0	0	0	0	2
Calliostoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Cidarina cidaris	0	0	0	0	0	0	0	0	0	0	0	0	0
Tegula pulligo	0	0	0	0	0	0	0	0	0	0	0	0	0
Halistylus pupoides	2	2	2	2	2	0	0	0	2	0	1	2	2
Acmaea mitra	1	1	0	0	0	0	0	0	0	0	0	0	0
Tectura persona	0	0	0	1	0	0	0	0	0	0	1	0	0
Lepeta caeca	0	1	0	0	0	0	0	0	0	0	0	0	0
Barleeia haliotiphila	0	0	0	0	0	0	0	0	0	0	0	0	0
Tachyrhynchus lacteolus	0	0	0	0	0	0	0	0	0	0	0	0	0
Micranellum crebricinctum	2	0	2	0	2	0	0	0	0	0	0	0	0
Petalochus compactus	0	0	0	0	0	0	0	0	0	0	0	0	0
Bittium eschritii	0	0	0	0	0	0	1	0	0	0	0	0	0
Bittium attenuatum	0	1	0	0	0	0	3	1	2	3	0	0	0
Bittium sp.	0	0	0	0	1	0	0	0	0	0	0	0	0
Cerithiopsis stejnegeri	0	0	0	0	0	0	0	0	0	0	0	0	0
Cerithiopsis truncatum	2	0	0	0	0	0	0	0	0	0	0	0	0
Cerithiopsis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichotropis cancellata	0	0	0	0	0	0	0	2	2	0	0	0	2
Calyptraea fastigiata	2	0	2	0	0	0	0	0	2	0	0	0	2
Crepidula dorsata	1	0	0	0	0	0	0	0	0	0	1	0	0
Crepidula nummaria	0	0	0	0	1	0	0	0	0	0	0	0	0
Natica clausa	0	0	0	0	1	0	0	1	0	0	0	0	0
Nitidiscala indianorum	0	0	1	0	0	0	0	0	0	0	1	0	0
Nitidiscala sp.	0	0	0	0	0	0	0	0	0	2	0	0	1
Epitonium greenlandicum	0	0	1	0	0	0	0	0	0	0	0	0	0
Opalia borealis	0	0	0	0	0	0	0	0	0	0	0	0	0
Eulima micans	1	0	0	0	0	0	0	0	0	0	0	0	0
Sabinella ptilocrinicola	0	0	0	0	0	0	0	0	0	1	0	0	0
Nucella emarginata	0	0	0	0	0	0	0	0	1	0	2	2	2
Ocenebra interfossa	2	0	0	0	0	0	0	0	2	0	1	0	0
Trophonopsis pacificus	0	0	0	0	0	0	0	0	0	0	0	0	1
Trophonopsis lasius	1	1	0	0	0	0	0	0	1	0	0	0	0
Alia gausapata	0	0	0	0	2	0	0	2	0	3	0	0	0
Alia permodesta	0	0	0	0	2	0	1	0	0	0	0	0	0
Amphissa columbiana	2	2	2	2	2	0	0	2	2	0	2	2	2

SPECIES	39	40	41	42	43	44	45	46	47	48	49	50	51
Searlesia dira	0	0	0	0	0	0	0	0	0	0	0	0	0
Nassarius mendicus	0	0	0	0	0	0	0	0	0	0	0	0	0
Olivella baetica	0	0	0	1	2	0	3	1	0	3	0	0	2
Granulina margariticula	1	1	0	0	0	0	0	0	0	0	0	0	0
Oenopota crebicostata	0	0	0	0	0	0	0	0	0	0	0	0	0
Oenopota turricula	0	0	0	0	1	0	0	0	0	0	0	0	0
Mitromorpha gracilior	0	0	0	0	0	0	0	0	0	0	1	0	0
Mitromorpha sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Turbonilla sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Odostomia sp.	2	0	0	0	0	0	1	0	0	0	0	0	0
Cylichnella culcitella	2	1	2	0	0	0	0	2	1	0	0	0	1
Cylichna attonsa	0	0	0	0	0	0	0	0	0	2	0	0	0
BIVALVES													
Acila castrensis	0	0	0	0	0	0	0	0	0	3	0	0	0
Nuculana sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Philobrya setosa	0	1	0	0	0	0	0	0	0	0	0	0	0
Glycymeris subobsoleta	4	4	3	3	3	3	0	2	0	0	3	3	1
Limatula subauriculata	0	0	0	0	0	0	0	2	0	0	0	0	0
Crenella decussata	0	0	0	0	0	0	0	0	0	0	0	0	0
Hinnites giganteus	2	2	2	0	2	0	0	2	0	0	0	2	0
Chlamys hastata	2	0	2	0	0	1	0	2	0	0	1	0	1
Chlamys rubida	2	0	0	1	2	2	0	2	0	0	1	0	0
Pododesmus cepio	0	0	0	0	0	0	0	0	0	0	0	0	1
Lucinoma tennuisculpta	0	0	0	0	0	0	0	0	0	0	0	0	0
Diplodonta orbella	0	0	2	2	0	0	0	0	0	0	0	2	0
Miodontiscus prolongatus	2	2	2	2	2	0	0	2	2	0	2	2	2
Cyclocardia crassidens	0	2	0	1	0	0	0	3	0	0	2	0	1
Cyclocardia ventricosa	2	1	2	1	0	1	0	3	0	1	0	0	0
Tridonta alaskensis	0	0	0	1	0	2	0	2	0	0	0	0	0
Nemocardium centifilosum	0	0	0	0	0	0	0	1	0	0	0	0	0
Clinocardium californiense	0	0	1	0	0	0	0	1	0	0	0	0	2
Clinocardium ciliatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Spisula falcata	0	0	0	0	0	0	0	0	0	0	0	0	1
Tellina nucleoides	0	1	0	0	0	2	2	0	0	0	0	2	2
Macoma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Gari californica	0	0	0	0	0	0	0	0	0	0	1	0	0
Semele rubropicta	0	0	0	0	0	0	0	0	0	0	0	0	0
Protothaca staminea	0	0	0	0	0	0	0	0	0	0	0	0	0
Humilaria kennerlyi	2	2	2	1	2	0	0	0	0	0	2	2	2
Psephidia lordi	0	0	0	1	1	0	0	3	0	3	0	2	0
Thracia sp.	0	0	0	0	0	0	0	0	0	1	0	0	0
Mya truncata	0	0	0	0	0	0	0	0	0	0	0	0	1
Hiatella arctica	0	0	0	2	0	0	0	0	0	0	0	0	0
Pandora bilirata	0	0	0	0	2	0	1	1	0	0	0	0	0
Pandora wardiana	0	0	0	0	0	0	0	0	0	2	0	0	0
Poromya sp.	0	0	0	0	0	0	0	0	0	0	0	0	0